

CEC DG WORKING GROUP: DG DEFINITION AND COST-BENEFIT ANALYSIS – POLICY INVENTORY

CONSULTANT REPORT

Prepared For:

California Energy Commission
Public Interest Energy Research Program

Prepared By:

Navigant Consulting, Inc.



July 9, 2004
500-04-049

Prepared By:

Navigant Consulting, Inc.
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Burlington, Massachusetts
Contract No. 500-01-008

Prepared For:

California Energy Commission

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Contract Manager

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Technology Systems Division

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CEC DG Working Group: DG Definition and Cost Benefit Analysis – Policy Inventory

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About this document...

This document contains the results from NCI's project to support the CEC DG Working Group in developing a policy position related to the definition of DG and the cost-benefit analysis of DG.

- The overall objective of this Navigant Consulting, Inc. (NCI) project is to support the CEC Distributed Generation Working Group (DGWG) in developing a consistent, commission-wide policy on Distributed Generation (DG)
- This policy will be used to support the CEC in its participation in the California Public Utilities Commission Order Instituting Rulemaking (OIR) on DG
- Specifically this work will provide the CEC with a policy position related to the definition of DG and the methodology for cost and benefit analysis of DG
- This document contains the policy inventory, analysis, observations and recommendations that resulted from this project

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Appendix

The DG OIR released on 16 March 2004 has six issues.

1. General issues
 - 2. Cost-Benefit Analysis for Customer and IOU Installations
 3. DG as a Utility Procurement Resource
 4. Net Metering
 5. Outstanding Interconnection and related Technical Issues
 6. DG Issues for the Future
 -> 7. Definition of DG
- OIR Issues***
- Suggested Separation of Definition Issue***

We propose that the question of “definition of DG” be:

- Considered as a separate issue rather than with Cost-Benefit as currently within the OIR.
- Addressed early, as it is important to all issues

Given the OIR schedule the priority areas that the Working Group will address are **DG Definition** and **Cost-Benefit Analysis**.

1. General issues
2. Cost-Benefit Analysis for Customer and IOU Installations
3. DG as a Utility Procurement Resource
4. Net Metering
5. Outstanding Interconnection and related Technical Issues
6. DG Issues for the Future
7. Definition of DG

**OIR
Issues**

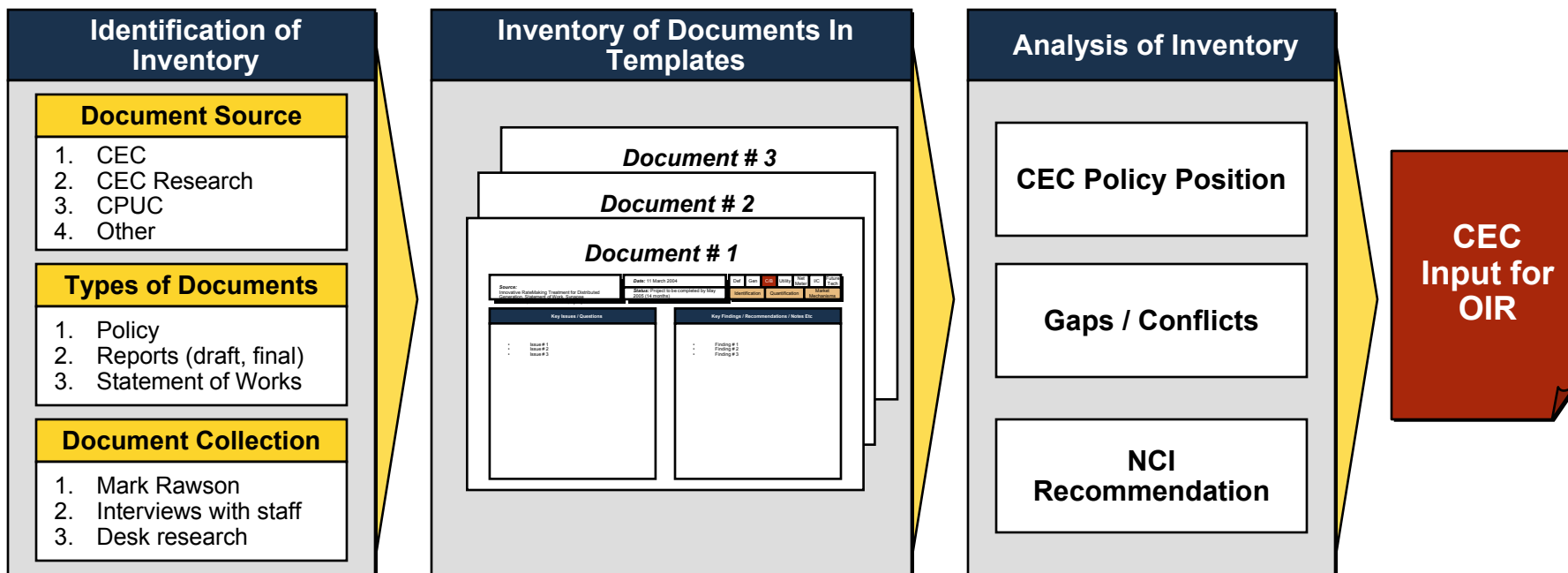
**Suggested
Separation
of Definition
Issue**

Section 2 of the OIR covers DG definition and Cost-Benefit Analysis.

2. Cost-Benefit Analysis for Customer and IOU Installations

- What is the proper definition of DG, including MW size ranges, for standardization across state agencies and programs?
- How might DG development affect the relative liabilities of ratepayers, utilities, DG owners and others?
- How are the avoided cost (and cost components) being developed in R.01-08-028 relevant to this inquiry? What changes are necessary for them to be applicable to the cost-benefit analysis of DG and net metered projects?
- Should a separate market structure (retail market or exchange) be created for the full range of DG technologies? Could this market be structured to maximize or aggregate the benefits at reasonable costs? How could consumer protections be established for any potential market structure?
- What are the positive and negative aspects of DG additions that need to be monetized?
- Which specific approaches to DG and net metering cost-benefit analyses should be adopted, and how should these analyses be employed by the Commission and the IOUs?
- Are standby charges and reserve requirements properly assessed and applied to DG projects?
- What are the emissions characteristics of present DG technologies, and in light of the pending ARB regulations, how should the Commission expect these characteristics to change over time?
- How should the Commission interpret the language of Pub.Util.Code 353.9, which requires that net costs of DG systems be recovered only within the DG owner's customer class? Should the Commission establish a separate customer class, or separate customer classes, to encompass DG installations, and contain net costs and benefits within each class?

The process followed in the inventory analysis is as illustrated below.



As part of the analysis, NCI also interviewed key staff to gain a broad perspective from other parts of CEC...

Interviews Completed (as of 21 April 2004)	
Person Interviewed	CEC Office
Virginia Lew	Energy Efficiency Financing Program
Joseph Wang	Energy Efficiency Financing Program
Daryl Mills	Energy Efficiency Financing Program
Tim Tutt	Emerging Renewables Program
Tony Brasil	Emerging Renewables Program
Lynn Marshall	Demand Forecast
David Aschukian	Supply Forecast

...discussions with CEC staff focused on DG related activities and their relevance to OIR issues.

Introduction List of Documents

The following documents were reviewed:

CEC		
CEC-	1	Distributed Generation Strategic Plan - June 2002
CEC-	2	Electricity and Natural Gas Assessment Report - December 2003
CEC-	3	Energy Action Plan - May 2003
CEC-	4	Integrated Energy Policy Report - December 2003
CEC-	5	Integrated Energy Policy Report Subsidiary Volume: Electricity and Natural Gas Assessment Report - December 2003
CEC-	6	Integrated Energy Policy Report Subsidiary Volume: Public Interest Energy Strategies Report - December 2003

CPUC		
CPUC-	1	Energy Action Plan - May 2003
CPUC-	2	Decision Adopting Interconnection Standards, December 2000 (D.00-12-037)
CPUC-	3	Interim Opinion: Implementation of Public Utilities Code Section 399.15(b), Paragraphs 4-7; Load Control and Distributed Generation Initiatives, March 2001 (D.01-03-073)
CPUC-	4	Interim Opinion: OIR to Establish Policies and Cost Recovery Mechanisms for Generation Procurement and Renewable Resource Development, October 2002 (D.02-10-062)
CPUC-	5	Interim Opinion: OIR to Establish Policies and Cost Recovery Mechanisms for Generation Procurement and Renewable Resource Development, January 2004 (D.04-01-050)
CPUC-	6	Opinion Approving the 2003 Servicing Order Concerning Southern California Edison Company and the California Department of Water Resources, December 2002 (D.02-12-071)
CPUC-	7	Opinion: OIR into Distributed Generation, March 2003 (D.03-02-068)
CPUC-	8	Final Opinion: OIR into Distributed Generation, April 2003 (D.03-04-060)
CPUC-	9	Opinion on Cost Responsibility Surcharge Mechanisms for Customer Generation Departing Load, April 2003 (D.03-04-030)

Other		
O-	1	A forecast of Cost Effectiveness - Avoided Costs and Externality Adders - CPUC - Jan 04
O-	2	DER Benefits Analysis Studies: Final Report - NREL - September 2003
O-	3	Evaluation Framework and Tools for DER - LBNL - February 2003

CEC Research		
R&D -	1	SOW: Energy and Environmental Economics Inc, Electrotek Concepts Inc, San Francisco Co-op DER
R&D -	2	SOW: New Power Technologies
R&D -	3	Installation, Operation and Maintenance Costs for DG; EPRI, February 2003
R&D -	4	Innovative Ratemaking Treatment for DG - Statement of Work (Synapse Energy Economics), March 2004
R&D -	5	SOW: Commonwealth Program under PIER Renewables
R&D -	6	San Francisco as a Distributed Energy Resource 'Test Bed' Site, M-Cubed, Electrotek Concepts, Energy & Env. Economics, Powerpoint Presentation.
R&D -	7	Final DG Scenario Development Report for Air Quality Impacts of DG, by University of California, Irvine; September 24, 2003.
R&D -	8	Distributed Utility Integration Test, PIER, 2 page note
R&D -	9	'Advanced Control Systems for the Grid' and DER, CADER International Symposium, January 2004.
R&D -	10	A framework for developing collaborative DER Programs: Working Tools for Stakeholders; Draft Report, E21 DER Partnership, December 2003.
R&D -	11	Air Pollution Emissions Impact Associated with Economic Market Potential of DG in California, DUA, June 2000
R&D -	12	Commonwealth Energy Biogas/PV Mini-Grid Renewable Resource Program, Project Prioritization, CH2M Hill and Itron, August 2003.
R&D -	13	Commonwealth Energy Biogas/PV Minigrid Renewables Resources Program, by Itron Inc., July 2003.
R&D -	14	Commonwealth Energy Biogas/PV Mini-Grid Renewables Resources Program, by Itron, Draft Report, August 2003
R&D -	15	DER Research Assessment Report, Addendum: 2003 Update, NCI
R&D -	16	Distributed Energy Resources with Combined Heat and Power Applications, LBNL, June 2003
R&D -	17	Distributed Power Integration Needs Assessment and Testing, DUIT White Paper, April 2001, Distributed Utility Associates
R&D -	18	Optimal Portfolio Methodology for Assessing DER Benefits for the Energynet, CADER International Symposium, January 2004.
R&D -	19	Pre-demonstration Summary Report, task 3.2.5: Micro Scale Technology Demonstration- Project Development and Engineering, Nov 7, 2003
R&D -	20	San Francisco PUC/Hetch Hetchy Baseline Data Report for DG Assessment Project, Draft Document, August 2003.
R&D -	21	SOW: Distributed Utility Integration Testing
R&D -	22	SOW: San Francisco PUC/ Hetch Hetchy, April 5, 2004
R&D -	23	Relative Merits of Distributed vs. Central PV Generation, Navigant Consulting and Kema-Xenergy, March 2004

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Appendix

Section 2 of the OIR covers DG definition.

2. Cost-Benefit Analysis for Customer and IOU Installations

- What is the proper definition of DG, including MW size ranges, for standardization across state agencies and programs?
- How might DG development affect the relative liabilities of ratepayers, utilities, DG owners and others?
- How are the avoided cost (and cost components) being developed in R.01-08-028 relevant to this inquiry? What changes are necessary for them to be applicable to the cost-benefit analysis of DG and net metered projects?
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- Which specific approaches to DG and net metering cost-benefit analyses should be adopted, and how should these analyses be employed by the Commission and the IOUs?
- Are standby charges and reserve requirements properly assessed and applied to DG projects?
- What are the emissions characteristics of present DG technologies, and in light of the pending ARB regulations, how should the Commission expect these characteristics to change over time?
- How should the Commission interpret the language of Pub.Util.Code 353.9, which requires that net costs of DG systems be recovered only within the DG owner's customer class? Should the Commission establish a separate customer class, or separate customer classes, to encompass DG installations, and contain net costs and benefits within each class?

NCI proposed that the OIR question on DG definition be recast as follows:

- What locations on the grid constitute DG connections?
- What is the MW size range for DG?
- What technologies are considered to be DG technologies?
- How does application affect the definition of DG?
- Are there other issues that must be considered in the definition of DG?

DG Definition Location

“Location” is viewed by NCI as the key criteria in defining DG.

Issues	Key Question	Sub-issues/questions
	<ul style="list-style-type: none"> What locations on the grid constitute DG connections? 	

Current Position	CEC	CEC Research	CPUC	Other
	<ul style="list-style-type: none"> Onsite or near the place of use Connected to the distribution level of the T&D grid 	<ul style="list-style-type: none"> Onsite May be interconnected with a large grid or isolated from the grid 		

Analysis of Current Position	Gaps	Conflicts
	<ul style="list-style-type: none"> Need to clarify whether interconnected and/or isolated? How is “near the place of use” defined? What is the definition of “distribution” level in CA? 	

NCI Recommendation	<ul style="list-style-type: none"> Distributed generation, by its nature is not “central” and is thus defined as either onsite or near place of use, located in the distribution level of the T&D system (contingent upon clarification of the definition of “near place of use” and “distribution level”)
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DG Definition Size

NCI does not view “system size” as a criteria for defining DG.

Issues	Key Question		Sub-issues/questions	
	<ul style="list-style-type: none"> What is the MW size range for DG? 			

Current Position	CEC	CEC Research	CPUC	Other
	<ul style="list-style-type: none"> 3kW to 10,000 kW 	<ul style="list-style-type: none"> 1kW to 20 MW Few to 50 MW (50MW limit due to permit construct in SoCAB) 15kW to 50 kW at load center, 1-10 MW for wholesale and retail markets Small and Modular Sized to maximize local advantage from customer perspective (match DER to load) 		

Analysis of Current Position	Gaps	Conflicts
		<ul style="list-style-type: none"> Range of sizes vary, one being a subset of another “Sized to match load” implies no size limit

NCI Recommendation	<ul style="list-style-type: none"> Size is implicitly defined if DG is at the distribution level (I.e. it will unlikely exceed a typical load size). Hence, size need not be a part of the DG definition Question: Is there some merit to defining the lower limit for DG size rather than an upper limit because benefits of very small size DG units are negligible, but would be substantial in large numbers or when aggregated?
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DG Definition Technologies

NCI does not view “eligible technologies” as a criteria for defining DG.

Issues	Key Question		Sub-issues/questions	
	<ul style="list-style-type: none"> What technologies are considered to be DG technologies? 			

Current Position	CEC	CEC Research	CPUC	Other
	<ul style="list-style-type: none"> PV 	<ul style="list-style-type: none"> DER includes DG, Distributed Storage and Demand Response DG technologies include PV, Batteries, Fuel Cells, Controls, Microturbines, Inverters, Combustion turbines, Storage devices, Reciprocating engines, Steam turbines, External combustion Stirling engines, Biomass, solar thermal, wind 		

Analysis of Current Position	Gaps	Conflicts

NCI Recommendation	<ul style="list-style-type: none"> Technologies have various characteristics, cost-performance attributes and competitive positions, which will change over time as technology develops. So long as the DG system is at the distribution level and can interconnect with the grid as per interconnection standards, technology is not viewed as a criteria in defining DG.
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DG Definition Applications

NCI does not view “applications” as a criteria for defining DG.

Issues	Key Question	Sub-issues/questions
	<ul style="list-style-type: none"> How does application affect the definition of DG? 	

Current Position	CEC	CEC Research	CPUC	Other
	<ul style="list-style-type: none"> Co-generation Not regarded as a supply side resource, but forecast as a form of demand reduction <ul style="list-style-type: none"> Till database on DG is completed to spot trends and forecast DG as supply resource Till there is a threshold aggregate DG installation As long as there is no control by the utility Meeting RPS requirements Reduce GHG Enhance reliability and power quality 			

Analysis of Current Position	Gaps	Conflicts

NCI Recommendation	<ul style="list-style-type: none"> DG can be used for many applications, which could vary by technology and customer group, as well as change with time. Application is thus not viewed as a criteria for defining DG.
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DG Definition Miscellaneous

There are no other issues that impact the definition of DG.

Issues	Key Question	Sub-issues/questions
	<ul style="list-style-type: none"> Are there other issues that must be considered in the definition of DG? 	

Current Position	CEC	CEC Research	CPUC	Other
	<ul style="list-style-type: none"> Consumer choice for securing electricity supply 	<ul style="list-style-type: none"> DG devices have historically not designed for control and dispatch by utilities DG provides locational value 		

Analysis of Current Position	Gaps	Conflicts

NCI Recommendation	<ul style="list-style-type: none"> Installation of DG systems alone does not enhance security of electricity supply – factors such as fuel supply, equipment performance, O&M also contribute towards ensuring supply security. Customer choice is one of the benefits of DG, but not the basis for definition. There may be a case for categorizing DG installations into “Utility Controlled DG” and “Customer Controlled DG”, which would require appropriate product designs, technical solutions, market mechanisms and regulations.
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After discussing NCI recommendations, the DGWG adopted the following definition of Distributed Generation:

Distributed Generation is electricity production interconnected to the T&D system that is on-site or close to the load center.

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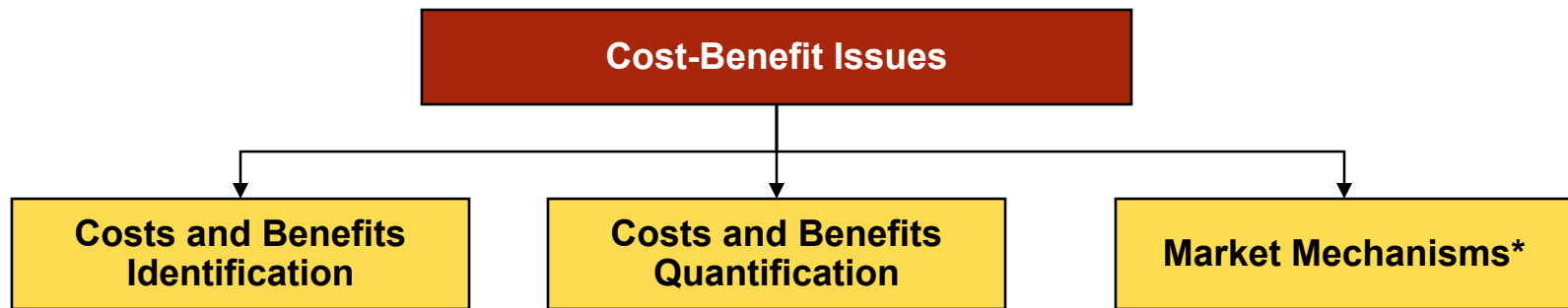
Section 2 of the OIR listed specific questions related to the Cost-Benefit issue.

2. Cost-Benefit Analysis for Customer and IOU Installations

- What is the proper definition of DG, including MW size ranges, for standardization across state agencies and programs?
- How might DG development affect the relative liabilities of ratepayers, utilities, DG owners and others?
- How are the avoided cost (and cost components) being developed in R.01-08-028 relevant to this inquiry? What changes are necessary for them to be applicable to the cost-benefit analysis of DG and net metered projects?
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- Which specific approaches to DG and net metering cost-benefit analyses should be adopted, and how should these analyses be employed by the Commission and the IOUs?
- Are standby charges and reserve requirements properly assessed and applied to DG projects?
- What are the emissions characteristics of present DG technologies, and in light of the pending ARB regulations, how should the Commission expect these characteristics to change over time?
- How should the Commission interpret the language of Pub.Util.Code 353.9, which requires that net costs of DG systems be recovered only within the DG owner's customer class? Should the Commission establish a separate customer class, or separate customer classes, to encompass DG installations, and contain net costs and benefits within each class?

Cost-Benefit Analysis Key Issues

The CEC DG Working Group has regrouped the Cost-Benefit questions into three sub-issues.



- The above issues will be analyzed for both, customer and IOU owned DG installations

* Potential mechanisms would include Rate and tariff structures, Wholesale and Retail Markets, Utility Contracts and Utility Planning

The key questions related to cost-benefit identification and quantification are:

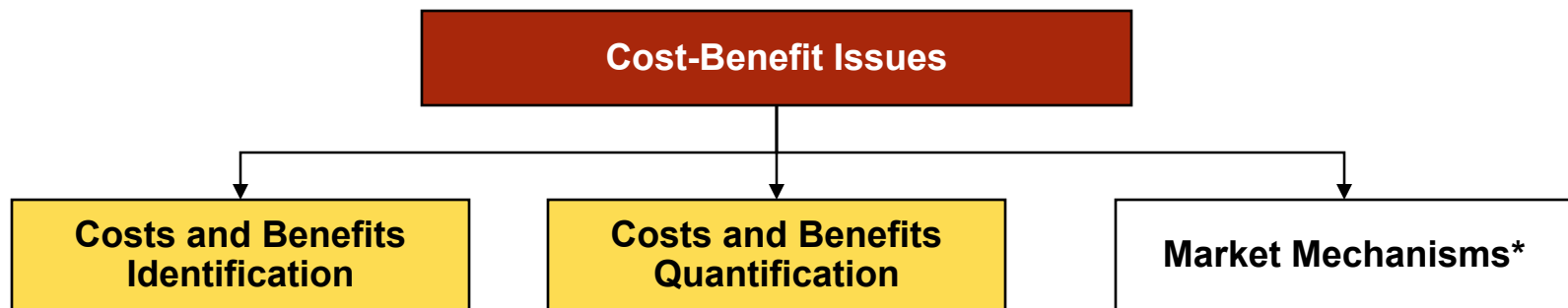
- ***Costs and benefits identification***
 - What are the costs and benefits of DG and under what circumstances will they be realized?
- ***Costs and benefits quantification***
 - What is the value of the benefits?
 - What is the cost to achieve these benefits?
 - Do costs and benefits vary by technology, and if so, how do we account for that?
 - When and where are these costs and benefits realized?
 - What are the methodologies to measure cost and benefit?
 - To whom is the cost and benefit allocated? (DG customer? DG Owner? Utility? Ratepayer? Taxpayer? Society?)
 - What is the accuracy and user-friendliness of available models to assess DG value and cost?

The key questions related to market mechanisms are:

- **Market Mechanisms** - What is the preferred mechanism to capture the value of DG benefits? Should there be different mechanisms to capture different values? What is the efficacy of these mechanisms to capture the value?
 - Potential mechanisms, which would consider aspects such as standby charges, need for separate DG customer class, assignment of risk, etc. include:
 - Rate and tariff structures
 - Wholesale and Retail Markets
 - Utility Contracts
 - Utility Planning
 - How and when will the DG market evolve and how would the preferred market mechanism change as the market evolves?
 - Should the Commission consider reforms to the net metering program, such as development of a wholesale transaction tariff to allow actual sales from the DG owner to the IOU? (Other net metering issues such as meter ownership and aggregate peak limit shall be addressed in other appropriate sections of the OIR)

Cost-Benefit Analysis Key Issues

The CEC DG Working Group will first work on the the cost benefit identification and quantification sub-issues, then the market mechanisms.



* Potential mechanisms would include Rate and tariff structures, Wholesale and Retail Markets, Utility Contracts and Utility Planning

The key questions related to cost-benefit identification are:

- ***Costs and benefits identification*** - What are the cost and benefits of DG and under what circumstances will they be realized?
- ***Costs and benefit quantification*** - What is the value of the benefits? What is the cost to achieve these benefits?
 - What is the methodology to measure cost and benefit?
 - What is the amount of the cost and benefit?
 - To whom is the cost and benefit appropriated? (DG customer? Utility? Ratepayer? Taxpayer? Society?)
 - What models are available to assess DG value and cost? What is their quality?

Since 2002, CEC's position on DG benefits has become more supportive.

	CEC
Current Position	Distributed Generation Strategic Plan - June 2002 <ul style="list-style-type: none"> • Environmental impacts of DG are unknown • Value propositions of DG are unknown
	Energy Action Plan - May 2003 <ul style="list-style-type: none"> • System benefits and cost of DG need to be determined • Some clean DG exempt from CRS • Some DG provides enhanced local reliability and high PQ • With proper inducements, some DG will become economic • DG can help state meet RPS goals • Promotes loading order of efficiency and conservation, renewables and renewable DG, clean fossil central station generation
	Integrated Energy Policy Report - December 2003 <ul style="list-style-type: none"> • DG benefits include improved reliability and power quality, peak-shaving options, security, and efficiency gains through the avoidance of line losses and the use of waste heat for heating and/or air conditioning. • Distributed generation can benefit utilities by deferring transmission and distribution construction, reducing resource acquisition costs, and supporting the level of ancillary services offered. • To the extent that electricity generated from renewable resources is sold under long-term contracts, it is immune to fluctuating natural gas prices and helps to stabilize the market, providing real economic benefit

The CPUC also believes benefits exist, including distribution system benefits, however it sees limitations for DG.

	CPUC
Current Position	<p>Interim Opinion: Implementation of Public Utilities Code Section 399.15(b), Paragraphs 4-7; Load Control and Distributed Generation Initiatives, March 2001 (D.01-03-073)</p> <ul style="list-style-type: none"> • Differentiated incentives for super-clean and renewable DG should be paid for enhancing reliability • Benefits of large (e.g., >1MW) DG include reduced grid supply of electricity, lower installation cost per kW, and greater environmental benefits in case of renewable installations • Encourages DG deployment to reduce peak-demand <p>Opinion: OIR into Distributed Generation, March 2003 (D.03-02-068)</p> <ul style="list-style-type: none"> • PG&E indicates that solicited distributed generation may also benefit the distribution system by providing voltage support, power factor improvement, and emergency back-up functions. • Potential consumer concerns in safety, interconnection, consumer protection and equipment costs • Distributed generation has the potential to reduce system peak demand in areas experiencing load growth. • Distributed generation has some potential to defer distribution system upgrades but this potential is time and location limited. • Distributed generation does not raise operational issues for the distribution system that are not addressed by interconnection standards. • The key to ensuring safe and reliable distribution services is not utility ownership of distributed generation, but the ability of the utility to control the distributed generation unit. • Utility ownership of a distributed generation unit designed to defer distribution system upgrades is not necessary to ensure the safe operation and reliability of the utility operated grid, provided physical assurance of the unit is provided. • The value of a distributed generation alternative is the value of deferral of a planned distribution upgrade for the time period of the deferral. • Physical assurance is required if distributed generation is to be considered as an alternative to distribution system upgrades. • If a distributed generation unit is sized, located, and installed consistent with the utility's planning process, and provides physical assurance, ownership by the utility is not required in order to provide distribution system benefits. • Costs of implementing the distributed generation policies adopted herein will likely be small and able to be incorporated into routine utility operations. • Installing a distributed generation unit carries with it a significant up front investment. • Public purpose program costs are non-bypassable by law. • If utilities incur implementation costs to implement these policies, it is reasonable to allow them to establish memorandum accounts to track these costs. • Compensation paid to a distributed generator that is selected as a wires alternative should not exceed the cost of the planned addition multiplied by the utility's short-term carrying cost of capital and the number of years of deferral

Cost-Benefit Analysis Identification

Continued...

	CPUC
Current Position	<p>Opinion on Cost Responsibility Surcharge Mechanisms for Customer Generation Departing Load, April 2003 (D.03-04-030)</p> <ul style="list-style-type: none"> • Some clean DG exempt from CRS <p>Final Opinion: OIR into Distributed Generation, April 2003 (D.03-04-060)</p> <ul style="list-style-type: none"> • Tracking of actual costs and benefits and ensuring recovery within customer classes will prevent cost shifting

Cost-Benefit Analysis Identification

Our next step was to identify the costs and benefits covered by CEC Research and other key documents.

Other	
O- 1	A forecast of Cost Effectiveness - Avoided Costs and Externality Adders - CPUC - Jan 04
O- 2	DER Benefits Analysis Studies: Final Report - NREL - September 2003
O- 3	Evaluation Framework and Tools for DER - LBNL - February 2003

CEC Research	
R&D - 1	SOW: Energy and Environmental Economics Inc, Electrotek Concepts Inc, San Francisco Co-op DER
R&D - 2	SOW: New Power Technologies
R&D - 3	Installation, Operation and Maintenance Costs for DG; EPRI, February 2003
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R&D - 23	Relative Merits of Distributed vs. Central PV Generation, Navigant Consulting and Kema-Xenergy, March 2004

Cost-Benefit Analysis Identification

Based on our research over the past 5 years we have a very good understanding of benefits and costs.

What are the Benefits?	
1	Support of RPS Goals
2	Mitigation of Market Power
3	Airborne or Outdoor Emissions
4	Reduced Security Risk to Grid
5	Reliability and Power Quality (Distribution System)
6	Voltage Support to Electric Grid
7	Enhanced Electricity Price Elasticity
8	NIMBY Opposition to Central Power Plants and Transmission Lines
9	Land Use Effects
10	Avoided T&D Capacity
11	System Losses
12	Combined Heat and Power/ Efficiency Improvement
13	Consumer Control
14	Lower Cost of Electricity
15	Consumer Electricity Price Protection
16	Reliability and Power Quality (DG Owner)
17	Ancillary Services

What are the Costs?	
1	Utility Revenue Reduction
2	Standby Charges
3	Incentives for Clean Technologies
4	Noise Disturbance
5	Indoor Emissions
6	Maintain System Reliability and Control Distributed Resources
7	Emissions Offsets
8	Airborne or Outdoor Emissions
9	DER Fuel Delivery Challenges
10	Equipment
11	Interconnection (system studies and upgrades)
12	Fuel
13	Maintenance
14	Insurance
15	Exemptions from Cost Responsibility Surcharges

Cost-Benefit Analysis Identification

The benefits activity should be prioritized based on the need for policy, the relative magnitude and tractability for each benefit.

What are the Benefits?		Policy Intervention Requirement ¹	Economic Magnitude ²	Analytic Tractability ³
1	Support of RPS Goals	Likely	Medium	Difficult
2	Mitigation of Market Power	Unlikely	Medium - Low	Medium
3	Airborne or Outdoor Emissions	Likely	Medium	Medium
4	Reduced Security Risk to Grid	Likely	High - Low	Difficult
5	Reliability and Power Quality (Distribution System)	Likely	Medium -Low	Medium
6	Voltage Support to Electric Grid	Unclear	Low	Medium
7	Enhanced Electricity Price Elasticity	Unclear	Medium -Low	Medium
8	NIMBY Opposition to Central Power Plants and Transmission Lines	Likely	Low	Difficult
9	Land Use Effects	Likely	Low	Difficult
10	Avoided T&D Capacity	Likely	High- Medium	Medium
11	System Losses	Likely	Medium-Low	Medium
12	Combined Heat and Power/ Efficiency Improvement	Unlikely	High	Easy
13	Consumer Control	Unlikely	Low	Difficult
14	Lower Cost of Electricity	Unlikely	High- Medium	Easy
15	Consumer Electricity Price Protection	Unlikely	Medium -Low	Medium
16	Reliability and Power Quality (DG Owner)	Unlikely	Medium	Easy
17	Ancillary Services	Likely	High-Medium	Medium

¹ Requirement for policy intervention based on the possibility of markets developing by that internalize the benefit without policy intervention

² Relative size of the benefit

³ The possibility and ease of quantifying the benefit (method, model and data availability)

Cost-Benefit Analysis Identification

In a similar manner, the costs should be prioritized based on the need for policy, the relative magnitude and tractability of each benefit.

What are the Costs?		Policy Intervention Requirement ¹	Economic Magnitude ²	Analytic Tractability ³
1	Utility Revenue Reduction	Likely	High	Medium
2	Standby Charges	Likely	Medium	Medium
3	Incentives for Clean Technologies	Likely	Medium	Easy
4	Noise Disturbance	Likely	Low	Difficult
5	Indoor Emissions	Likely	Low	Difficult
6	Maintain System Reliability and Control Distributed Resources	Likely	High-Low	Difficult
7	Emissions Offsets	Unclear	Medium	Easy
8	Airborne or Outdoor Emissions	Unclear	Medium	Medium
9	DER Fuel Delivery Challenges	Unclear	Medium-Low	Easy
10	Equipment	Unlikely	High	Easy
11	Interconnection (system studies and upgrades)	Unlikely	High-Low	Easy
12	Fuel	Unlikely	High	Easy
13	Maintenance	Unlikely	High	Easy
14	Insurance	Unlikely	Low	Easy
15	Exemptions from Cost Responsibility Surcharges	Regulation in place	High	Easy

¹ The possibility of markets developing that internalize the cost without policy intervention

² Relative size of the cost

³ The possibility and ease of quantifying the cost (method, model and data availability)

Cost-Benefit Analysis Identification

To unlock the benefits, DG will need to be incorporated into the planning process, provide physical assurance and increase market penetration.

Benefits		Planning Process	Utility Ownership	Physical Assurance	Market Penetration	Advances in Technology	Change in Utility Ops	Data Transparency	Customer Ownership
1	Support of RPS Goals	R	H	R	R	H	I	I	I
2	Avoided Wholesale Energy Purchase	R	I	R	R	H	I	I	I
3	Airborne or Outdoor Emissions	I	I	I	H	H	I	I	I
5	Reliability and Power Quality (System)	R	H	R	H	I	R	H	I
6	Voltage Support to Electric Grid	H	H	R	H	I	R	H	I
7	Enhanced Electricity Price Elasticity	I	I	I	R	I	I	R	R
10	Avoided T&D Capacity	R	I	R	I	I	R	R	I

R – Required
H – Helps
I - Irrelevant

The key questions related to cost-benefit quantification are:

- ***Costs and benefits identification*** - What are the cost and benefits of DG and under what circumstances will they be realized?
- ***Costs and benefit quantification*** - What is the value of the benefits? What is the cost to achieve these benefits?
 - What is the methodology to measure cost and benefit?
 - What is the amount of the cost and benefit?
 - To whom is the cost and benefit appropriated? (DG customer? Utility? Ratepayer? Taxpayer? Society?)
 - What models are available to assess DG value and cost? What is their quality?

Cost-Benefit Analysis Quantification

At the same time, benefits should be examined in their entirety to understand the tradeoffs among benefits and stakeholders.

Benefits		DG Owner	Utility*	Ratepayers*	Society
1	Support of RPS Goals				
2	Mitigation of Market Power				
3	Airborne or Outdoor Emissions				
4	Reduced Security Risk to Grid				
5	Reliability and Power Quality (Distribution System)				
6	Voltage Support to Electric Grid				
7	Enhanced Electricity Price Elasticity				
8	NIMBY Opposition to Central Power Plants and Transmission Lines				
9	Land Use Effects				
10	Avoided T&D Capacity				
11	System Losses				
12	Combined Heat and Power/ Efficiency Improvement				
13	Consumer Control				
14	Lower Cost of Electricity				
15	Consumer Electricity Price Protection				
16	Reliability and Power Quality (DG Owner)				
17	Ancillary Services				

Priority Benefits
 Receives the Benefit
 Not impacted

* Some utility benefits will flow down to ratepayers


Cost-Benefit Analysis Quantification

Likewise, costs should be examined in their entirety to understand the tradeoffs among costs and stakeholders.

Costs		DG Owner	Utility*	Ratepayers*	Society
1	Utility Revenue Reduction				
2	Standby Charges				
3	Incentives for Clean Technologies				
4	Noise Disturbance				
5	Indoor Emissions				
6	Maintain System Reliability and Control Distributed Resources				
7	Emissions Offsets				
8	Airborne or Outdoor Emissions				
9	DER Fuel Delivery Challenges				
10	Equipment				
11	Interconnection (system studies and upgrades)				
12	Fuel				
13	Maintenance				
14	Insurance				
15	Exemptions from Cost Responsibility Surcharges				

 Priority Costs

 Receives the Cost

 Not impacted

* Some utility costs will flow down to ratepayers

Cost-Benefit Analysis Quantification

It is likely we will need several methods since the nature of these benefits varies. For example, some benefits are best viewed on a central basis while others on a distributed basis.

Benefits		DG Owner	Utility*	Ratepayers*	Society	Central vs Distributed
1	Support of RPS Goals					Central
2	Mitigation of Market Power					Central
3	Airborne or Outdoor Emissions					Central/Distributed
4	Reduced Security Risk to Grid					Central
5	Reliability and Power Quality (Distribution System)					Distributed
6	Voltage Support to Electric Grid					Distributed
7	Enhanced Electricity Price Elasticity					Central
8	NIMBY Opposition to Central Power Plants and Transmission Lines					Distributed
9	Land Use Effects					Distributed
10	Avoided T&D Capacity					Distributed
11	System Losses					Central
12	Combined Heat and Power/ Efficiency Improvement					Distributed
13	Consumer Control					Distributed
14	Lower Cost of Electricity					Distributed
15	Consumer Electricity Price Protection					Distributed
16	Reliability and Power Quality (DG Owner)					Distributed
17	Ancillary Services					Central/Distributed

 Priority Benefits
  Receives the Benefit
  Not impacted

* Some utility benefits will flow down to ratepayers


Cost-Benefit Analysis Quantification

Likewise, some costs are best viewed on a distributed rather than central basis.

Costs		DG Owner	Utility*	Ratepayers*	Society	Central vs Distributed
1	Utility Revenue Reduction					Central
2	Standby Charges					Distributed
3	Incentives for Clean Technologies					Central
4	Noise Disturbance					Distributed
5	Indoor Emissions					Distributed
6	Maintain System Reliability and Control Distributed Resources					Central
7	Emissions Offsets					Central
8	Airborne or Outdoor Emissions					Central/ Distributed
9	DER Fuel Delivery Challenges					Central
10	Equipment					Distributed
11	Interconnection (system studies and upgrades)					Distributed
12	Fuel					Distributed
13	Maintenance					Distributed
14	Insurance					Distributed
15	Exemptions from Cost Responsibility Surcharges					Central

 Priority Costs

 Receives the Cost

 Not impacted

* Some utility costs will flow down to ratepayers

Cost-Benefit Analysis Quantification

Reaching agreement and acceptance on methods (and the data required for these methods) will be a challenge for these high priority benefits.

Benefits		DG Owner	Utility	Ratepayers	Society	Central vs Distributed
1	Support of RPS Goals					Central
2	Mitigation of Market Power					Central
3	Airborne or Outdoor Emissions					Central/Distributed
4	Reduced Security Risk to Grid					Central
5	Reliability and Power Quality (Distribution System)					Distributed
6	Voltage Support to Electric Grid					Distributed
7	Enhanced Electricity Price Elasticity					Central
8	NIMBY Opposition to Central Power Plants and Transmission Lines					Distributed
9	Land Use Effects					Distributed
10	Avoided T&D Capacity					Distributed
11	System Losses					Central
12	Combined Heat and Power/ Efficiency Improvement					Distributed
13	Consumer Control					Distributed
14	Lower Cost of Electricity					Distributed
15	Consumer Electricity Price Protection					Distributed
16	Reliability and Power Quality (DG Owner)					Distributed
17	Ancillary Services					Central/Distributed



Cost-Benefit Analysis Quantification

In contrast to benefit quantification, cost data/methods/models have more acceptance.

Costs		DG Owner	Utility	Ratepayers	Society	Central vs Distributed
1	Utility Revenue Reduction					Central
2	Standby Charges					Distributed
3	Incentives for Clean Technologies					Central
4	Noise Disturbance					Distributed
5	Indoor Emissions					Distributed
6	Maintain System Reliability and Control Distributed Resources					Central
7	Emissions Offsets					Central
8	Airborne or Outdoor Emissions					Central/ Distributed
9	DER Fuel Delivery Challenges					Central
10	Equipment					Distributed
11	Interconnection (system studies and upgrades)					Distributed
12	Fuel					Distributed
13	Maintenance					Distributed
14	Insurance					Distributed
15	Exemptions from Cost Responsibility Surcharges					Central

Priority Benefits

Data

Accepted

Publicly Available

Unavailable

Not impacted

Methods/Models

Accepted

Publicly Available

Unavailable

Cost-Benefit Analysis Quantification

A range of the potential value of the benefits is known for many of these benefits. The range of benefits varies by location, time, technology and application.

Benefits		DG Owner	Utility	Ratepayers	Society
1	Support of RPS Goals				\$0-15/MWh
2	Mitigation of Market Power		\$45-85/MWh		
3	Airborne or Outdoor Emissions				\$3-8/MWh
4	Reduced Security Risk to Grid	Unknown	Unknown	Unknown	Unknown
5	Reliability and Power Quality (Distribution System)		\$5-15/MWh	\$5-15/MWh	
6	Voltage Support to Electric Grid		Unknown		
7	Enhanced Electricity Price Elasticity			\$0-8.96/MWh	
8	NIMBY Opposition to Central Power Plants and Transmission Lines				Unknown
9	Land Use Effects				Unknown
10	Avoided T&D Capacity		\$1-16/MWh		
11	System Losses		\$0.50-12/MWh		
12	Combined Heat and Power/ Efficiency Improvement	\$5-60/MWh			Known
13	Consumer Control	Unknown			
14	Lower Cost of Electricity	Known			
15	Consumer Electricity Price Protection	Known			
16	Reliability and Power Quality (DG Owner)	\$1-50/kWh			
17	Ancillary Services			Unknown	

☐ Receives the Benefit

☒ Not impacted

Known = Generally known values not found in CEC or CPUC research

Cost-Benefit Analysis Quantification

A range of the potential value of the costs is known for many of these costs. The range of costs varies by location, time, technology and application.

Costs		DG Owner	Utility	Ratepayers	Society
1	Utility Revenue Reduction		Known	Unknown	
2	Standby Charges	Unknown			
3	Incentives for Clean Technologies			\$3-8/MWh	Known
4	Noise Disturbance	Unknown			Unknown
5	Indoor Emissions	Unknown			Unknown
6	Maintain System Reliability and Control Distributed Resources		Unknown	Unknown	
7	Emissions Offsets	Known			
8	Airborne or Outdoor Emissions				Known
9	DER Fuel Delivery Challenges	Unknown			Unknown
10	Equipment	\$200-33000/kW			
11	Interconnection (system studies and upgrades)	\$0-30,000/inst	Known		
12	Fuel	\$0-3/kWh			
13	Maintenance	\$0-344/kW-yr			
14	Insurance	Known			
15	Exemptions from Cost Responsibility Surcharges			\$0-27/MWh	

☐ Pays the Cost

☒ Not impacted

Known = Generally known values not found in CEC or CPUC research

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Appendix

The CEC has developed a perspective on the benefits and costs of distributed generation based on a wealth of research in this area.

- Traditional regulatory approaches (e.g., incentive programs, customer class ratemaking) that are average-based or technology specific are not sufficient to encourage benefits
 - To understand the net benefits, benefits and costs need to be analyzed on a holistic basis across all stakeholders (e.g., a benefit to one will likely be a cost to another).
 - Some benefits/costs are distributed (i.e. depend on location and time), others are central (i.e. independent of location). Locational benefits are independent of customer class.
 - Benefits are mostly technology neutral and driven by application.
- A major challenge for DG costs and benefits is to gain acceptance for available models and to make available the data needed for those models
 - High priority benefits all have available models, but all stakeholders do not accept these models.
 - Most data needed for these models are not publicly available.
- Unlocking full potential of DG will require an evolution of market mechanisms over time as better C/B methods are developed and data becomes available
 - There are many costs and benefits to consider and the ability to analyze these benefits varies widely.
 - Project-specific methods (i.e., brute force) can be implemented now. More sophisticated methods, based on a system-wide approach, are under developed and should be implemented as they become available.
 - Regulatory activity should be prioritized based on the most important benefits and costs

Based upon these observations, Energy Commission staff recommends several items for the CPUC to consider in their DG proceeding.

- The definition of DG should not be dependent on size, technology, application, or ownership.
- In the near term, the CPUC should develop a common model or models for utilities and other stakeholders (including other California agencies) to use for determining costs and benefits that includes the high priority costs and benefits identified in this white paper.
- In the short-term, the CPUC should implement a project-based cost/benefit methodology that would include a more transparent distribution planning process than currently required of the utilities.
- A system-wide approach for DG C/B should be adopted later as better methods, models and data that can more accurately determine the locational benefits become available and gain acceptance.
- An interim step would be to require the utilities to partner with the Energy Commission to validate a systems-level model and approach that optimizes the transmission and distribution system (e.g., New Power/Optimal Technologies).
- The CPUC should consider the proposed process steps; identify costs and benefits; develop method to quantify costs and benefits; quantify costs and benefits and, develop and implement market mechanisms to allocate costs and benefits.

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Appendix



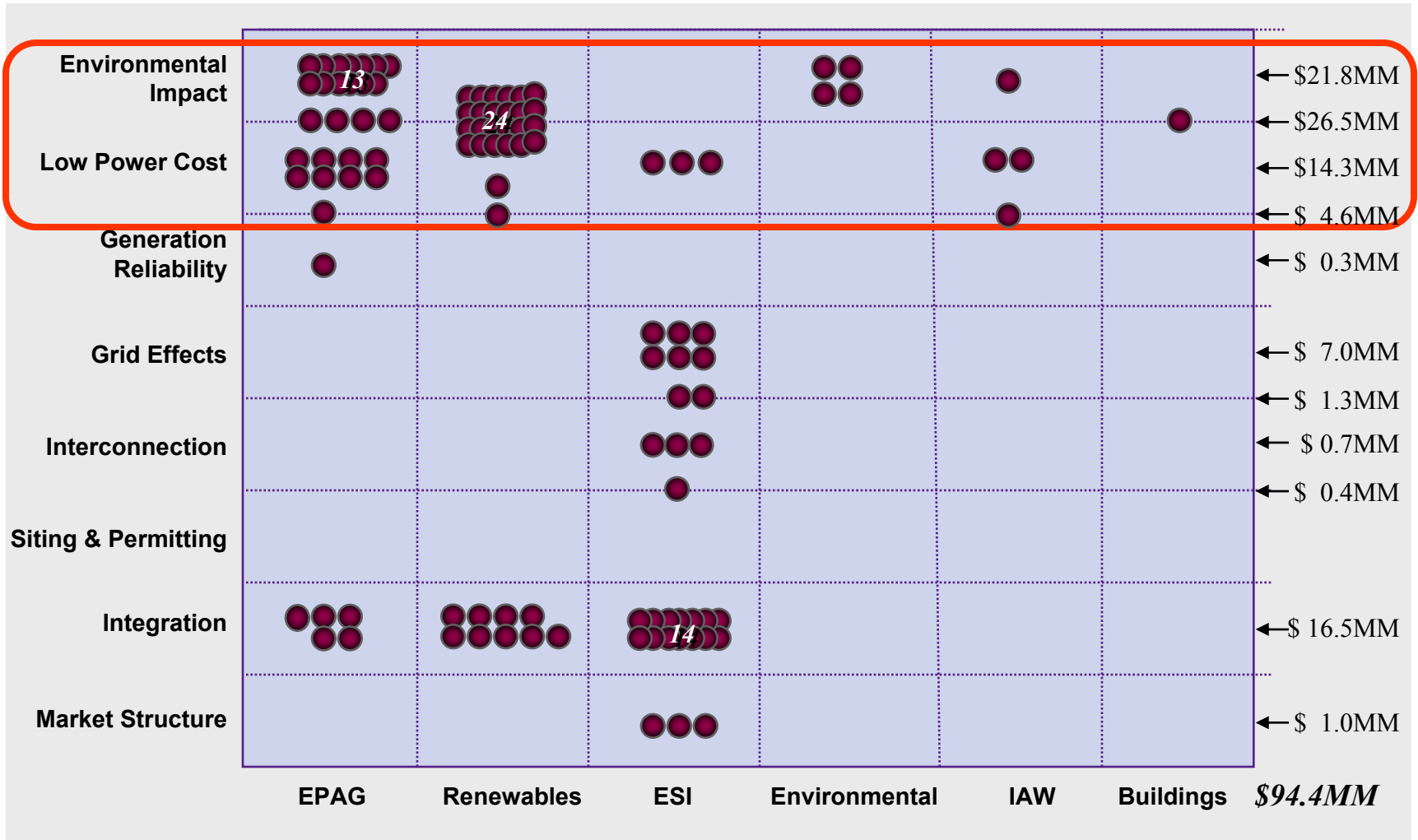
Appendix A – CEC PIER DER

108 projects are DG related and total \$94.4M out of over \$370M in total PIER-funded R&D.

- All six PIER program areas have projects that are DG related
 - Environmentally Preferred Advanced Generation (EPAG)
 - Renewables
 - Energy Systems Integration (ESI)
 - Environmental
 - Buildings
 - Industrial, Agriculture and Water (IAW)
- Research projects address broad spectrum of DG issues

Appendix A CEC PIER DER

71% of portfolio focused on reducing environmental impact and developing lower cost power.



Appendix A CEC PIER DER

PIER DER Research and Development Portfolio (1 of 10)

	Subject Area	Issue (see footnote)	Title	Research Question Addressed	CEC Contract #	Commission Contract Manager	CEC Funding (thousands \$)	Project Completion Date
1	EPAG	A	Durability of catalytic combustion systems	Can we improve catalytic combustion technology for on-engine field testing in 1.5 MW Kawasaki gas turbine engine?	500-97-033	Avtar Bining	1,316	3/31/02 Completed
2	EPAG	A	Low NOx gas turbine combustors for distributed power generation	Can we develop gas turbine semiradiant burner (GTSB) for gas turbine applications?	500-97-031	Avtar Bining	879	3/31/02 Completed
3	EPAG	A	Xonon ultra-low combustion in small multican turbines	Can we develop component technologies and complete engineering design of a multi-can catalytic combustion system?	500-01-030	John Henry Beyer	\$2,998	12/31/2003
4	EPAG	A	Development of a partial oxidation gas turbine for combined electricity and hydrogen enriched fuel gas production	Can we develop, test and demonstrate a partial oxidation gas turbine in combination with energy conversion devices?	500-02-005	John Henry Beyer	\$1,480	3/31/2004
5	EPAG	A	Catalytic combustor - fired gas turbine for distributed power and cogeneration applications	Can we develop a multi-can catalytic combustion system suitable for application in two gas turbines?	500-98-041	John Henry Beyer	\$815	3/31/2004
6	EPAG	A	Catalytic combustor-fired industrial gas turbine	Can we advance catalytic combustion to the production entry level using Solar's Taurus 60 industrial gas turbine?	500-01-045	John Henry Beyer	\$3,000	9/30/2004
7	EPAG	A	Microturbine generator operation on alternative fuels	Can we reduce emissions and develop multi-fuel capability for microturbine generator (MTG) technology?	500-00-020 #1, 2, 3	Art Soinski	\$2,348	3/30/2005
8	EPAG	A	Experimental study of jet mixing in rich-burn/quench-mix/lean-burn (RQL) combustors	Can we understand jet mixing as applied to high-temperature, high-pressure combustion typical of gas turbines?	500-00-025	Art Soinski	\$269	3/31/2005
9	EPAG	A	Ultra-Low NOx combustion system for a 13.5 kW gas turbine generator	Can California develop distributed generation capacity without sacrificing environmental quality considerations?	500-01-010	Avtar Bining	\$2,404	3/31/2006
10	EPAG	A	A 500 kW zero-emission gas-fired power plan	How durable and reliable is the fossil-fueled, zero-emission power generation system based on rocket engine designs?	500-01-013	John Henry Beyer	\$2,003	3/31/2006

A = Environmental impact
B = Low Power Cost
C = Generation reliability

D = Grid effects
E = Interconnection
F = Siting and permitting

G = Integration
H = Market Structure

Appendix A CEC PIER DER

PIER DER Research and Development Portfolio (2 of 10)

	Subject Area	Issue (see footnote)	Title	Research Question Addressed	CEC Contract #	Commission Contract Manager	CEC Funding (thousands \$)	Project Completion Date
11	EPAG	A	Catalytic Combustion Retrofit of a Gas Turbine at Sonoma Development Center	Can we advance catalytic combustion to the production entry level using a industrial gas turbine?	500-01-037	John Henry Beyer	\$105	3/31/2006
12	EPAG	A	Low NOx GT Combustor	Can we bring to market gas turbine monolithic injector utilizing surface stabilized combustion technology?	500-00-004	Avtar Bining	\$1,312	3/31/2006
13	EPAG	A	Field Test of a Catalytic Combustion System for Non-Ammonia Control of Gas Turbine NOx Emissions			John Henry Beyer	\$600	6/30/2006
14	EPAG	A/B	Collaboration with ASERTTI	Can we develop nationally accepted procedures to test and evaluate electricity generation systems that are used as DER?	Planned	Art Soinski	\$107	10/1/2005
15	EPAG	A/B	An Ultra-Low Emissions System Development Project	Can we develop a natural gas fueled, reciprocating engine system that reduces emissions and installation costs while increasing efficiency?	500-02-002	Avtar Bining	\$2,995	3/30/2006
16	EPAG	A/B	Low Cost, High Efficiency, Ultra-Low NOx ARICE Solution Using HCCI Combustion	Can we develop a homogenous charge compression ignition based engine/generator that can produce > 200 kW for more than 1,000 hours?	500-02-003	Avtar Bining	\$1,999	6/30/2005
17	EPAG	A/B	Energy efficient, low emission, cost effective micropilot ignited natural gas engine driven genset for deregulated mtk	Can we develop a the MicroPilot diesel-cycle natural gas engine technology?	500-97-041	Shahid Chaudry	\$983	3/31/2002 Completed
18	EPAG	B	75-kW molten-carbonate fuel cell (MCFC) stack verification test	Can we demonstrate the energy-producing performance of advanced design MCFC in a 75kW generator?	500-97-039	Avtar Bining	\$1,000	3/31/02 Completed
19	EPAG	B	A novel steam reforming reactor for fuel cell distributed power generation	Can we develop a novel steam reforming process to convert natural gas to a H-containing mixture on a small scale?	500-97-038	Art Soinski	\$350	3/31/02 Completed
20	EPAG	B	Emerging distributed resource technologies	Can DER provide a substantial portion of the energy alternatives now demanded by California electricity users?	100-98-001 Target 23	Jairam Gopal	\$429	12/31/2000 Completed

A = Environmental impact
B = Low Power Cost
C = Generation reliability

D = Grid effects
E = Interconnection
F = Siting and permitting

G = Integration
H = Market Structure

Appendix A CEC PIER DER

PIER DER Research and Development Portfolio (3 of 10)

	Subject Area	Issue (see footnote)	Title	Research Question Addressed	CEC Contract #	Commission Contract Manager	CEC Funding (thousands \$)	Project Completion Date
21	EPAG	B	Advanced fuel cells	Can we develop low cost, very efficient, planar solid oxide fuel cells (SOFC's) to operate at 650-800 C?	500-00-022	Art Soinski	\$103	12/31/2002
22	EPAG	B	Reduced temperature, electrode-supported planar (RTESP) solid oxide fuel cell (SOFC) submodule	Can we design, fabricate, operate and test a 3 kW sub-scale SOFC stack and balance of plant?	500-01-020	Art Soinski	\$3,000	3/31/2006
23	EPAG	B	Testing, optimization and demonstration of an EPAG microturbine	Can we use novel technologies to improve the performance of a 300kW microturbine?	500-01-012	John Henry Beyer	\$2,867	3/31/2006
24	EPAG	B	An integrated distributed power system using a PEM fuel cell and an autothermal cyclic reformer (ACR)	Is the autothermal cyclic reformer-based fuel processor integrateable with a proton exchange membrane (PEM) fuel cell?	500-01-022	Avtar Bining	\$1,959	3/31/2006
25	EPAG	B	Collaboration with Federal Energy Management Program	Are there federal sites in California with CHP potential worth developing?	Federal Grant \$150k	Avtar Bining	\$0	12/31/2005
26	EPAG	B/C	Reduced-temperature solid oxide fuel cell (SOFC) operating on the direct oxidation of natural gas	Can we develop a commercially viable planar SOFC with high reliability, reduced operating temperature and high efficiency	500-01-014	Art Soinski	\$3,000	3/31/2006
27	EPAG	C	Fuel cell development and demonstration	Can we demonstrate performance and reliability of a molten carbonate fuel cell (MCFC) electric generating tech?	500-97-011 #2	Avtar Bining	\$300	1/31/00 Completed
28	EPAG	G	Distributed resources demonstration	How can small DG systems be seamlessly integrated into existing electric distribution systems?	500-97-011 #4	Jamie Patterson	\$450	1/31/00 Completed
29	EPAG	G	Analysis and technology transfer for fuel cells	How do fuel cell systems and fuel cell/microturbine hybrid systems operate? How can we improve transfer at NFCRC?	500-98-052	Art Soinski	\$306	6/30/00 Completed
30	EPAG	G	Micro turbine generator (Distributed Generation)	How do small gas turbines respond in distributed electrical generation applications?	500-97-012 #8	Avtar Bining	\$500	6/30/01 Completed
31	EPAG	G	Solid-oxide fuel cell / micro turbine generation hybrid	Can we integrate two dissimilar electricity producing distributed generation technologies as an integrated system?	500-97-012 #7	Art Soinski	\$2,000	6/30/01 Completed
32	EPAG	G	Microturbine generators, fuel cells and hybrid systems development	Can we standardize testing and reporting procedures for microturbine generators? Develop steady-state analytical tools?	500-99-028 #1, 2, 3	Art Soinski	\$1,409	7/14/2004
			Environmentally Preferred Advanced Generation (EPAG) Total \$				\$43,286	

A = Environmental impact
B = Low Power Cost
C = Generation reliability
D = Grid effects

E = Interconnection
F = Siting and permitting
G = Integration
H = Market Structure

Appendix A CEC PIER DER

PIER DER Research and Development Portfolio (4 of 10)

	Subject Area	Issue (see footnote)	Title	Research Question Addressed	CEC Contract #	Commission Contract Manager	CEC Funding (thousands \$)	Project Completion Date
1	Renewables	A/B	Powerguard California Manufacturing	How can PV costs be lowered to help increase customer choice and make electricity more affordable?	500-97-049	Arnold Ward	\$959	3/31/02 Completed
2	Renewables	A/B	The Next Generation Turbine Development Project	Can wind turbine costs be lowered to \$0.025/kwhr at sizes that make wind DG feasible?	500-97-032	Michelle Pantoya	\$950	3/31/02 Completed
3	Renewables	A/B	Powertherm Product Development	How can PV provide added energy value to customer choice?	500-97-046	Arnold Ward	\$542	3/31/02 Completed
4	Renewables	A/B	Residential Electric Power Security	How can PV system prices be lowered while simultaneously increasing reliability and value?	500-97-047	Shahid Chaudry	\$426	3/31/02 Completed
5	Renewables	A/B	The Flex-Microturbine Uniquely Adapted to Low Pressure Biomass Gas	Can a small modular biomass system be developed to utilize low Btu gases that reduce costs and lower NOx emissions?	500-99-030	Prab Sethi	\$984	3/31/2004
6	Renewables	A/B	Utilization of Waste Renewable Fuels in Boiler with Minimization of Pollutant Emissions	How can low quality biomass fuels be utilized to existing biomass boilers and lower NOx emissions?	500-98-037	Valentino Tiangco	\$982	3/31/2004
7	Renewables	A/B	Application of Small Modular Biopower System for Power Generation from Forest Residue	How feasible is a small modular gasification system for combined heat and power application?	500-99-029	Prab Sethi	\$646	3/31/2004 Completed
8	Renewables	A/B	Wind Turbine Company EMD Turbines	Can load mitigation techniques produce a wind turbine with an unsubsidized COE <\$0.03/kWh at 15 mph wind sites?	500-00-019	Dora Yen	\$1,300	6/30/2004
9	Renewables	A/B	CW - 3.1 Dairy Waste to Energy	How to optimize the energy recovery from dairy waste that can minimize environmental costs?	500-00-036 #3.1	Zhiqin Zhang	\$3,275	3/31/2005
10	Renewables	A/B	SMUD - 3.1 UNI-SOLAR PV Roofing	How can PV systems be deployed faster, with lower costs for California buildings?	500-00-034 #3.1	Joe Mc Cabe	\$1,508	3/31/2005

A = Environmental impact
B = Low Power Cost
C = Generation reliability

D = Grid effects
E = Interconnection
F = Siting and permitting

G = Integration
H = Market Structure

Appendix A CEC PIER DER

PIER DER Research and Development Portfolio (5 of 10)

	Subject Area	Issue (see footnote)	Title	Research Question Addressed	CEC Contract #	Commission Contract Manager	CEC Funding (thousands \$)	Project Completion Date
11	Renewables	A/B	SMUD - 3.3 SunTile: Mainstreaming PV for Residential Rooftops	How can PV modules be aesthetically integrated into California's concrete tile roofs?	500-00-034 #3.3	Joe Mc Cabe	\$1,500	3/31/2005
12	Renewables	A/B	SMUD - 3.8 Solar Dish Concentrating with Stirling Engine	Can concentrating solar play a role in large DG energy solutions for California?	500-00-034 #3.8	Joe Mc Cabe	\$1,301	3/31/2005
13	Renewables	A/B	SMUD - 4.5 Distributed Generation Geartrain for Megawatt Turbines	SMUD - 4.5 Distributed Generation Geartrain for Megawatt Turbines	500-00-034 #4.5	Dora Yen	\$1,299	3/31/2005
14	Renewables	A/B	SMUD - 3.5 Optimization of Residential PV Systems	How can insulation be added to residential PV systems to provide dual DG value?	500-00-034 #3.5	Joe Mc Cabe	\$1,127	3/31/2005
15	Renewables	A/B	CW - 3.2 Building Integrated PV Evaluation	How can PV systems be evaluated for AC watts increasing consumer confidence and markets?	500-00-036 #3.2	Zhiqin Zhang	\$870	3/31/2005
16	Renewables	A/B	CW - 3.3 Building Integrated PV Generation	How can government facilities be used for highest value building integrated PV systems?	500-00-036 #3.3	Zhiqin Zhang	\$828	3/31/2005
17	Renewables	A/B	SMUD - 4.2 Maximum Power Point Tracker & Operational Dispatch	How can unused stored energy from PV be deployed to reduce super peaking?	500-00-034 #4.2	Joe Mc Cabe	\$709	3/31/2005
18	Renewables	A/B	Hetch Hetchy - Project 4.3 Energy Storage for Renewable Generation	How can energy storage increase the economic effectiveness of wind and PV renewable energy resources?	500-01-042 #4.3	Valentino Tiangco	\$319	3/31/2005
19	Renewables	A/B	SMUD - 1.2 PV Markets and Technologies (SEPA)	How can SMUD PV experiences be replicated at other utilities?	500-00-034 #1.2	Joe Mc Cabe	\$316	3/31/2005
20	Renewables	A/B	SMUD - 3.4 Flat Roof Mounting Approaches	How can PV balance of systems costs in be lowered for commercial buildings?	500-00-034 #3.4	Joe Mc Cabe	\$100	3/31/2005

A = Environmental impact
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H = Market Structure

Appendix A CEC PIER DER

PIER DER Research and Development Portfolio (6 of 10)

	Subject Area	Issue (see footnote)	Title	Research Question Addressed	CEC Contract #	Commission Contract Manager	CEC Funding (thousands \$)	Project Completion Date
21	Renewables	A/B	SMUD - 3.2 BIPV Mounting Approaches for New Construction	How can PV balance of systems costs in be lowered for sloped roof buildings?	500-00-034 #3.2	Joe Mc Cabe	\$99	3/31/2005
22	Renewables	A/B	SMUD - 3.7 PV and Evaporative Cooling	How can needle peaks from HVAC loads be reduced with PV systems?	500-00-034 #3.7	Joe Mc Cabe	\$50	3/31/2005
23	Renewables	A/B	SMUD - 3.6 Remote Dispatch & PV Irrigation	How can water be pumped with PV providing additional peak utility power?	500-00-034 #3.6	Joe Mc Cabe	\$77	3/31/2005
24	Renewables	A/B	Powerwheel Demonstration	Can the very low head (<10') drops common in irrigation canals supply DG hydropower at a competitive COE?	500-97-037 #3.7	Shahid Chaudry	\$200	3/31/2007
25	Renewables	B	Photovoltaic Power Generation with Direct Current Applications		500-02-014	George Simons	\$25	
26	Renewables	B/C	Development and demonstration of 50kW small modular biopower system	Can we develop and demonstrate a biomass fueled grid-connected 50kW small modular biopower system to provide utility-grade power and heat?	500-03-020	Prab Sethi	\$725	3/31/2008
27	Renewables	G	Information to Support High-Value Photovoltaic Power Applications	How can resource assessment be used to reduce peaking utilities with solar systems?	500-00-023 #26 Target #84.1	George Simons	\$27	6/30/02 Completed
28	Renewables	G	Renewable Energy Applications in Distributed Generation	How to maximize the value of using renewables for distributed generation?	500-00-023 #29 Target #84.5	George Simons	\$13	6/30/02 Completed
29	Renewables	G	Strategic Value Analysis: Power Flow Simulations and Development of Renewable RD&D Performance Goals	How to reduce costs and improve the value of renewable energy utilization in California?	500-00-031	Prab Sethi	\$730	6/30/2004
30	Renewables	G	Strategic Value Analysis: GIS Development	How can GIS tools improve the utilization value of renewables for electricity generation?	500-00-030	Prab Sethi	\$280	6/30/2004
31	Renewables	G	Hetch Hetchy - Project 3.2 Biomass Project Distributed Generation Value Analysis	How can small modular biomass generators provide high strategic value to the electricity system?	500-01-042 #3.2	Prab Sethi	\$730	3/31/2005
32	Renewables	G	Hetch Hetchy - Project 3.1 Distributed Generation Assessment	What are the best locations for renewables DG with improved reliability impacts?	500-01-042 #3.1	Prab Sethi	\$591	3/31/2005
33	Renewables	G	Wind Energy resource Modeling and Measurement	Can we develop high-resolution regional wind maps for improving wind resources and to improve mapping capacity by conducting a tall tower/sodar wind monitoring program?	500-03-006	Michael Kane	\$425	9/1/2005
34	Renewables	G	Tracking the Sun for High Value Grid Electricity		500-03-000	George Simons	\$1,214	1/31/2007
35	Renewables	G	Wind Forecasting		500-02-014	Michael Kane	\$850	
			Renewables Total \$				\$25,977	

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Appendix A CEC PIER DER

PIER DER Research and Development Portfolio (7 of 10)

	Subject Area	Issue (see footnote)	Title	Research Question Addressed	CEC Contract #	Commission Contract Manager	CEC Funding (thousands \$)	Project Completion Date
1	Energy Systems Integration	B	Emerging distributed resource technologies	Can distributed resources provide a substantial portion of the energy alternatives now demanded by users?	500-00-023 #2 Target 33	Jairam Gopal	\$461	12/31/2001 Completed
2	Energy Systems Integration	B	2 kWh Flywheel energy storage system	Can we use a flywheel energy storage system as a load shifting technology to be used during peak load periods?	500-98-036	Jamie Patterson	\$1,057	3/31/2004 Completed
3	Energy Systems Integration	B	Demonstration of ZBB Energy Storage Systems		500-03-031	David Chambers	\$1,873	3/31/2008
4	Energy Systems Integration	D	Development /demonstration of methodology to assess value of DER	How can we measure and quantify the grid benefits or impacts that DER generates for the distribution and transmission system?	500-01-039	Linda Kelly	\$617	6/30/2004
5	Energy Systems Integration	D	Distributed utility integration test - DUIT	What are the grid effects of integrating large numbers of DER into the distribution system?	500-01-033	Dave Michel	\$2,000	3/31/2004
6	Energy Systems Integration	D	SF COOP Regional Solutions Project	Can a "test bed" demonstrate and measure the impacts of actual distributed energy resources on a distribution system?	500-03-009	Dave Michel	\$596	4/30/2005
7	Energy Systems Integration	D	NREL-Modeling and Testing of Effects of Unbalanced Loading on Voltage Regulation	Will unbalanced loading from DG on different phases of the distribution system cause voltage regulation problems?	500-03-011	Mark Rawson	\$325	9/30/2007
8	Energy Systems Integration	D	NREL- Modeling Interconnection and Anti-Islanding of DER	Can a more realistic resonant test circuit quality factor (Q) that better reflects real-world conditions be determine and used for anti-islanding performance testing?	500-03-011	Mark Rawson	\$510	9/30/2007
9	Energy Systems Integration	D	Distributed utility integration test - DUIT Phase II	What are the grid effects of integrating large numbers of DER into the distribution system?		Dave Michel	\$2,976	3/31/2008
10	Energy Systems Integration	D/E	Interconnection rules and processes - Focus II	How should rule 21 be modified to level cost and insure safety? What are the impacts of DER on distribution system?	500-00-013	Dave Michel	\$546	12/31/2004

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Appendix A CEC PIER DER

PIER DER Research and Development Portfolio (8 of 10)

	Subject Area	Issue (see footnote)	Title	Research Question Addressed	CEC Contract #	Commission Contract Manager	CEC Funding (thousands \$)	Project Completion Date
11	Energy Systems Integration	D/E	Interconnection rules and processes - Focus	How should rule 21 be modified to level cost and insure safety? What are the impacts of DER on distribution system?	500-03-012	Dave Michel	\$710	3/31/2006
12	Energy Systems Integration	E	Interconnection guidebook	How can interconnection processes be standardized? What are the best practices for interconnection?	500-00-014	Dave Michel	\$65	10/31/2003 Completed
13	Energy Systems Integration	E	Support for the IEEE 1547 interconnection	Can we develop a nationwide standard for interconnection?	500-00-015	Dave Michel	\$72	12/31/2004
14	Energy Systems Integration	E	NREL-Universal Interconnection Device	Can a cost effective interconnection device be developed that is universal to inverter and rotating DG systems?	500-03-011	Mark Rawson	\$604	9/30/2007
15	Energy Systems Integration	E/F	Interconnection requirements for distributed energy resources - Focus I	What are the interconnection requirements for DER? Land use issues for CA? Permitting issues for local permitting authorities?	700-99-010	Jon Edwards	\$395	12/31/01 Completed
16	Energy Systems Integration	G	Distributed resources demonstration - SDG&E	Can we effectively implement DER?	500-97-011 #4	Jamie Patterson	\$450	1/31/00 Completed
17	Energy Systems Integration	G	Demonstration of intelligent software agents for control and scheduling of distributed generation - Phase I	Can we effectively schedule distributed generation and/or other energy resources in the marketplace?	500-98-040	Jamie Patterson	\$554	3/31/02 Completed
18	Energy Systems Integration	G	Distributed energy resources public website	How can we use the CEC's website to promote and coordinate DER activities in the state?	100-98-001 #34	Mark Rawson	\$160	12/31/02 Completed
19	Energy Systems Integration	G	Intelligent software agents for control and scheduling of distributed generation - Phase II	Can we effectively schedule distributed generation and/or other energy resources in the marketplace?	500-00-016	Jamie Patterson	\$500	3/31/2004
20	Energy Systems Integration	G	CERTS microgrid laboratory test planning	What are the interconnection impacts of a microgrid?	150-99-003 #3	Mark Rawson	\$450	12/31/2004

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Appendix A CEC PIER DER

PIER DER Research and Development Portfolio (9 of 10)

	Subject Area	Issue (see footnote)	Title	Research Question Addressed	CEC Contract #	Commission Contract Manager	CEC Funding (thousands \$)	Project Completion Date
21	Energy Systems Integration	G	EPRI-Retail Business Strategy		500-00-0023, #11	Jairam Gopal	\$51	Completed
22	Energy Systems Integration	G	EPRI-Distribution System Integration		500-00-0023, #12	Jairam Gopal	\$64	Completed
23	Energy Systems Integration	G	EPRI-Business Strategies		500-00-0023, #45	Jairam Gopal	\$73	Completed
24	Energy Systems Integration	G	EPRI-Distribution System Strategic Advantage		500-00-0023, #13	Jairam Gopal	\$45	Completed
25	Energy Systems Integration	G	EPRI-Business Strategies		500-00-0023, #10	Jairam Gopal	\$73	Completed
26	Energy Systems Integration	G	DR Online Resources Guide Update		500-02-014	Mark Rawson	\$136	3/1/2004
27	Energy Systems Integration	G	CEIDS Consortium for Electric Infrastructure to support a Digital Society		500-02-014	Laurie ten Hope	\$500	
28	Energy Systems Integration	G	CERTS microgrid laboratory testing	What are the interconnection impacts of a microgrid?	500-03-024	Bernard Treanton	\$2,955	12/31/2007
29	Energy Systems Integration	G	Energy Storage Enabled Renewable MicroGrid™ Power Network		500-03-028	David Chambers	\$986	3/31/2008
30	Energy Systems Integration	H	Distributed resources information and tools for business strategy development	What is the size of the opportunity for DER and what are the most attractive applications?	100-98-001 #10 Target #34	Jairam Gopal	\$596	12/31/02 Completed
31	Energy Systems Integration	H	Identifying opportunities in distributed generation - 2001	What are the application characteristics and technical requirements for the strategic utilization of gas-fired DG?	500-00-022 #7	Art Soinski	\$179	12/31/02 Completed
32	Energy Systems Integration	H	NREL-Innovative Ratemaking Treatment for DER	Can innovative concepts and methods be used for ratemaking treatment of DER?	500-03-011	Mark Rawson	\$176	9/30/2007
			Energy Systems Integration (ESI) Total \$				\$20,755	

A = Environmental impact
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Appendix A CEC PIER DER

PIER DER Research and Development Portfolio (10 of 10)

	Subject Area	Issue (see footnote)	Title	Research Question Addressed	CEC Contract #	Commission Contract Manager	CEC Funding (thousands \$)	Project Completion Date
1	Environmental	A	Emissions testing and certification guidelines for distributed generators	What would be an acceptable testing protocol and criteria for any DG devices applying for "fleet" certification in CA?	100-98-001	Matt Layton	\$90	11/30/00 Completed
2	Environmental	A	Distributed generation in natural environment	Environmental rank of DG? What is the appropriate level of governance and policy for DG to improve air quality?			\$46	9/30/02 Completed
3	Environmental	A	Improvement of short range dispersion models	How to improve short models that would reflect localized impact of DG and central power plants?	500-01-038	Kelly Berkinshaw	\$437	7/1/02 - 6/30/04
4	Environmental	A	Regional and overall air quality impact: widespread distributed generation application in Southern California	What is the air quality impact of widespread use of DG in Southern California?	500-00-033	Kelly Berkinshaw	\$699	3/31/2005
			Environmental Total \$				\$1,272	
1	Industrial Agricultural Water	A	Combustion of pullulating "off-gases" for DG (planned)	Can we economically modify turbines to effectively combust off-gases and reduce flaring and/or emissions from them?	500-02-016	Larry Rabin	\$1,000	9/31/02 - 9/31/04
2	Industrial Agricultural Water	B	Storage technology to meet industry customer needs (planned)	Does the basic technology work? Can it respond to needs in a customer setting?			\$1,000	9/31/02 - 9/31/04
3	Industrial Agricultural Water	B	Methodology to Optimize Compressed Air Energy Storage for Industry		500-01-026	Rajesh Kapoor	\$178	3/01/02 - 5/15/03
4	Industrial Agricultural Water	B/C	Flywheel Energy Storage System (FESS) Demonstration for Electrified Transit Networks			Pramod Kulkarni	\$891	3/31/2008
			Industrial Agricultural Water (IAW) Total \$				\$3,069	
1	Buildings	A/B	Impact assessment of building integrated PV for California	What is the performance of the building integrated PV?	400-99-011 Project #6.4	Chris Scruton	\$50	3/31/2004
			Buildings Total \$				\$50	
			Total PIER \$				\$94,409	

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Appendix B

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Technology		Size		Location		



Installation, Operation, and Maintenance Costs for DG, EPRI, February 2003. (R&D-3)

Key Findings/Recommendations/Notes, Etc.

Technologies

- Both mature and emerging

Size

- 1kw to 20 MW

Location on Grid

- On-site power generation

Appendix B

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Technology		Size			Location	



Distributed Utility Integration Test, PIER, 2 page note (R&D-8)

Key Findings/Recommendations/Notes, Etc.

Size

- DER are small, modular

Technology

- DER are generation and storage devices. These devices, and their systems, include:
 - Fuel cells
 - Microturbines
 - PV
 - Batteries
 - Combustion turbines
 - Engines
 - Controls
 - Inverters
 - Storage

Appendix B

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Technology		Size		Location		



Distributed Power integration Needs Assessment and Testing, DUIT White Paper, Distributed Utility Associates, April 2001 (R&D-17)

Key Findings/Recommendations/Notes, Etc.

Technologies

- DER includes distributed generation and distributed storage
- Modular technologies, such as:
 - PV
 - Cogeneration
 - Recip engines
 - Fuel Cells
 - Small battery storage system
 - Steam or gas turbines
 - Microturbines

Size

- Historically sized to maximize local advantages, usually from the customer's perspective i.e., matching DER to local loads

Location

- May be interconnected with a large grid or isolated from the grid
- Locational value is high enough that its distributed value is important to its economics and operation

Other

- Dispatch and control by the utility, for the utility's benefit has not been a major consideration in the design of DG systems

Appendix B

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Technology		Size			Location	



Energy Action Plan - May 2003 (CEC-3 and CPUC-1)

Key Issues / Questions

- Standardize definitions of eligible distributed generation technologies across agencies to better leverage programs and activities that encourage distributed generation.

Key Findings / Recommendations / Notes Etc

Appendix B

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Technology		Size			Location	



Distributed Generation Strategic Plan - June 2002 (CEC-1)

Key Issues / Questions

Technology

- Presently, distributed generation is not regarded as a supply-side resource. Instead, DG is embedded into the Energy Commission demand forecast as a form of demand reduction. It may be possible, once the database of DG installations has been completed, to spot trends and to forecast DG as a supply-side resource.

Key Findings / Recommendations / Notes Etc

Location

- DG is electric generation connected to the distribution level of the transmission and distribution grid usually located at or near the intended place of use.

Appendix B

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Technology		Size			Location	



Integrated Energy Policy Report - December 2003 (CEC-4)

Key Issues / Questions

Key Findings / Recommendations / Notes Etc

Definition

- Although different from direct access, distributed generation offers consumers a range of choices for securing their electricity supplies. Distributed generation, including cogeneration and self-generation, has tremendous potential to help meet California's growing energy needs as an additional generation source and an essential element of customer choice. Its use offers potential benefits that extend to customers, utilities, and the system as a whole and can be used strategically to meet the policy objectives of the RPS and reduce greenhouse gases.

Appendix B

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Technology		Size			Location	



Integrated Energy Policy Report Subsidiary Volume: Electricity and Natural Gas Assessment Report - December 2003 (CEC-5)

Key Issues / Questions	Key Findings / Recommendations / Notes Etc
	<p>Definition</p> <ul style="list-style-type: none"> As a result of various initiatives, there is renewed interest in choice. Distributed generation and self-generation through cogeneration facilities are also expressions of choice. <p>Technology</p> <ul style="list-style-type: none"> Emerging technologies require further breakthroughs in research and development before they will be considered commercially viable on a central-station scale. Solar PV has shown its usefulness as a distributed generation technology. However, the levelized cost of 42.72¢ per kWh for a 50 MW is uncompetitive at a central-station scale.

Appendix B

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Technology		Size			Location	



Integrated Energy Policy Report Subsidiary Volume: Public Interest Energy Strategies Report - December 2003 (CEC-6)

Key Issues / Questions

Definition

- According to the Energy Action Plan, "Distributed generation is an important local resource that can enhance reliability and provide high quality power without compromising environmental quality."

Key Findings / Recommendations / Notes Etc

Size/Location

- DG (i.e., electricity that is generated on-site or near the place of use, typically ranging in capacity from 3 to 10,000 kW)

Appendix B

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Technology		Size		Location		



Final DG Scenario Development Report for Air Quality Impacts of DG, by University of California, Irvine; September 24, 2003. (R&D-7)

Key Findings/Recommendations/Notes, Etc.

Size

- DG evaluated including from a few kW to 50 MW:
 - 50MW limit due to the permitting construct in South Coast Air Basin (SoCAB)

Technologies

- Likely to be implemented in SoCAB:
 - Natural gas fired combustion turbines (up to 50MW)
 - Natural gas fired reciprocating ICE
 - Solar (PV)
 - Fuel cells
 - Gas turbine fuel cell hybrid
 - NG fired micro turbine generators
 - External combustion stirling engines

Appendix B

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Technology		Size			Location	



Optimal Portfolio Methodology for Assessing DER Benefits for the Energynet, CADER International Symposium, January 2004. (R&D-18)

Key Findings/Recommendations/Notes Etc

Technologies

- DER options include:
 - Demand Response
 - DG
 - Capacitors

Appendix B

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Technology		Size			Location	



SOW: Commonwealth Program under PIER Renewables (R&D-5)

Key Findings/Recommendations/Notes, Etc.

Dairy waste to energy technologies evaluated include:

- Covered lagoons
- High rate phased digestion
- European manure digestion
- Thermal hydrolysis
- Pyrolysis
- Heat drying

Appendix B

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Technology		Size			Location	



SOW: San Francisco PUC/ Hetch Hetchy, April 5, 2004 (R&D-22)

Key Findings/Recommendations/Notes, Etc.

Size

Project 3.2: Biomass DG valuation analysis and project development for public utility service territories

- Primary technology focus on small modular biomass
 - Micro generation of 15 kW to 50 kW, at load center
 - Small generation in 1-10 MW, for sale to wholesale and retail markets, as stand alone or in combination with storage . Fossil fuel hybrid

Appendix B

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Technology		Size			Location	



SOW: Energy and Environmental Economics Inc, Electrotek Concepts Inc, San Francisco Co-op DER (R&D-1)

Key Findings/Recommendations/Notes, Etc.

DER Technologies

Demand side options

- Targeted efficiency measures
- Locally dispatchable load curtailment, particularly thorough CPA, ISO and utility programs
- “smart” meters and programmable thermostats
- Real time pricing and other innovative demand response programs
- Absorption cycle chillers

Local Supply side options

- NG fired cogen (microturbines or larger)
- Cogeneration with district heating and cooling
- Solar thermal and photovoltaic
- Fuel cells
- Bio-diesel and bio-gas fired generators
- Wind power

Appendix B

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Technology		Size			Location	



Air Pollution Emissions Impact Associated with Economic Market Potential of DG in California, DUA, June 2000 (R&D-11)

Key Findings/Recommendations/Notes, Etc.

DG Technologies Considered

- Microturbines
- Advanced turbine system
- Combustion turbines
- Diesel engines
- Dual fuel engines
- Otto/spark engines
- Phosphoric acid fuel cells
- PEM fuel cells

Appendix C Cost Benefit Summary



Appendix C – Cost Benefit Summary

Appendix C Cost Benefit Summary

Benefits		DG Owner	Utility	Ratepayers	Society
1	Support of RPS Goals				

R&D-10

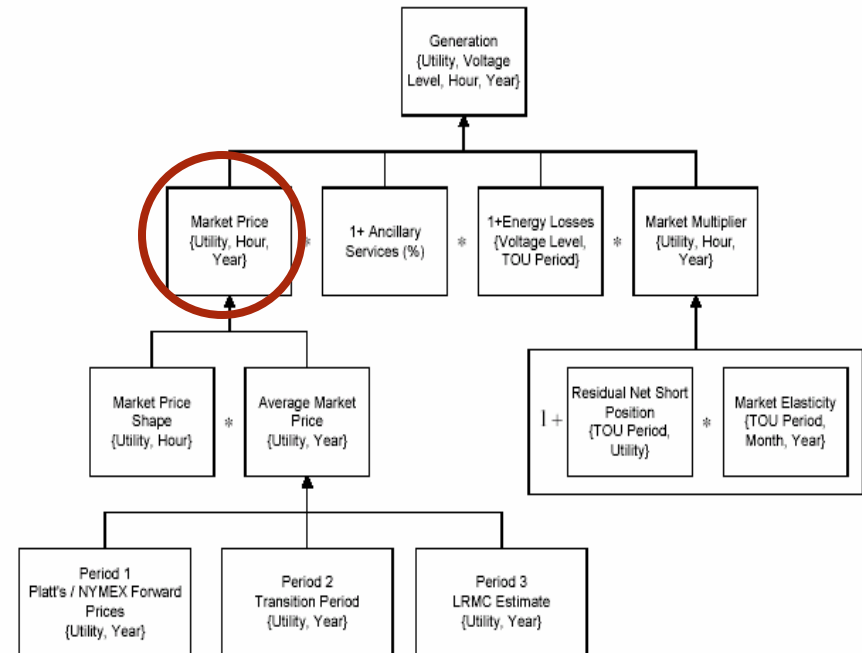
Benefit	Value	Comments
Renewable Energy Credit	\$0.0-\$15/MWh	Valid only for renewable energy

Appendix C Cost Benefit Summary

	Benefits	DG Owner	Utility	Ratepayers	Society
2	Avoided Wholesale Energy Purchase				

O-1

- Variable by hour and location. The annual forecast of generation costs avoided is allocated according to an hourly price shape obtained from historic data that reflect a workably competitive market environment. These hourly costs further vary by location, depending on locational capacity constraints and fuel costs.
-\$45-\$85/MWh average price until 2023



R&D-10

Benefit	Value	Comments
Avoided wholesale energy purchases	<ul style="list-style-type: none"> Forward electricity contracts for short term (firm prices includes energy and capacity) Long-term power costs for long term 	<ul style="list-style-type: none"> System wide benefit of DER is lower market prices (reduces output from high marginal production cost, mitigates capacity shortage and counters energy seller's market power) California Measurement Advisory Committee (CALMAC) acknowledges importance of price effect of system demand reduction. It estimates the on-peak escalator at 5x if market power is exercised and 2.5x if market power conditions are mitigated.

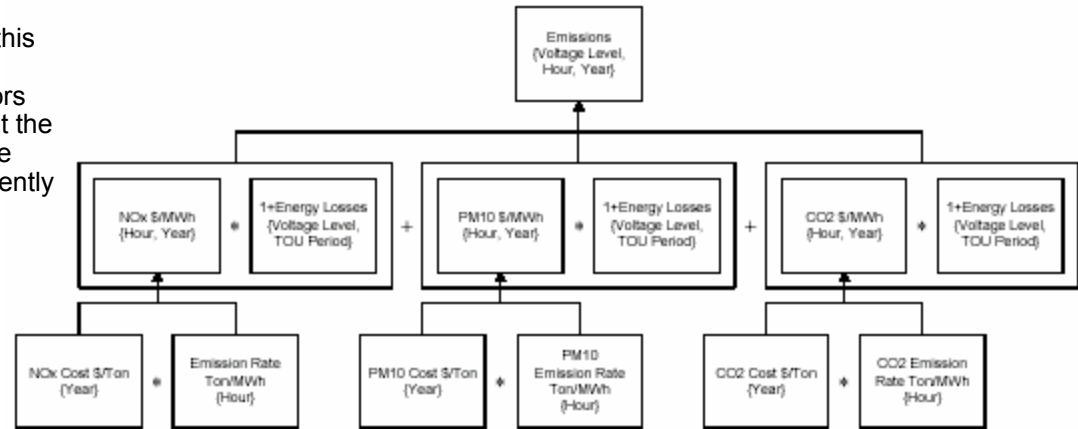
Appendix C Cost Benefit Summary

Benefits		DG Owner	Utility	Ratepayers	Society
3	Airborne or Outdoor Emissions	<i>Economic Incentives</i>			<i>Clean Air</i>

O-1

-E3 categorized environmental costs into priced and unpriced emissions, which are accounted for separately in this avoided cost analysis. The priced emissions refer to those emissions that are regulated and for which energy generators must purchase some type of allowances or credits to offset the impact of the emissions produced from their operations. The unpriced emissions represent an externality that is not presently embedded in energy prices and is added directly to the generation and T&D

avoided costs.
- \$3 to \$8/MWh



O-3 Methods/Models that can be used to Quantify:

- The national policy models could help quantify national emissions.
- Urban Airshed Model (UAM): Simulates regional transport of pollutants and their physical/chemical transformations spatially and temporally.
- Tracking and Analysis Framework (TAF): Links together into an integrated framework the key acid deposition components of pollutant emissions; control costs; atmospheric transport and deposition; environmental effects on visibility, lakes, soils, and human health; and valuation of these effects.

Appendix C Cost Benefit Summary

Benefits		DG Owner	Utility	Ratepayers	Society
3	Airborne or Outdoor Emissions	<i>Economic Incentives</i>			<i>Clean Air</i>

R&D-10

Benefit	Value	Comments
Reduced central station emissions	<ul style="list-style-type: none"> Emission reduction credits NO_x abatement technologies for 150MW facility cost 0.117¢-0.289¢/kWh Permitting fees for engines in South Coast Air Quality Management District ranges between \$184-\$2,088 depending on new/renewal engine fee and size of engine. Source testing costs \$2,000-\$4,000 per test every three years. CO₂ emission offset cost ranges between \$3-12/ton CO₂ emitted (in Oregon) 	<ul style="list-style-type: none"> Valid for renewable technologies For fossil technologies, same or lower relative to central station Abatement equipment cost avoided or reduced Reduced permitting costs if DER is exempt from air permitting requirements Avoided CO₂ emission, though currently not regulated except in Oregon DER emission being lower than central station (though can be high for diesel recip engines)

Appendix C Cost Benefit Summary



Benefits		DG Owner	Utility	Ratepayers	Society
4	Reduced Security Risk to Grid				

O-3 Methods/Models that can be used to Quantify:
 One potential method to quantify this benefit would be to survey insurance carriers to determine how they would calculate the risk premium and value grid reliability.

O-3 Note: Efficiency solutions don't provide reactive power

Appendix C Cost Benefit Summary

Benefits		DG Owner	Utility	Ratepayers	Society
5	Reliability and Power Quality (System)				

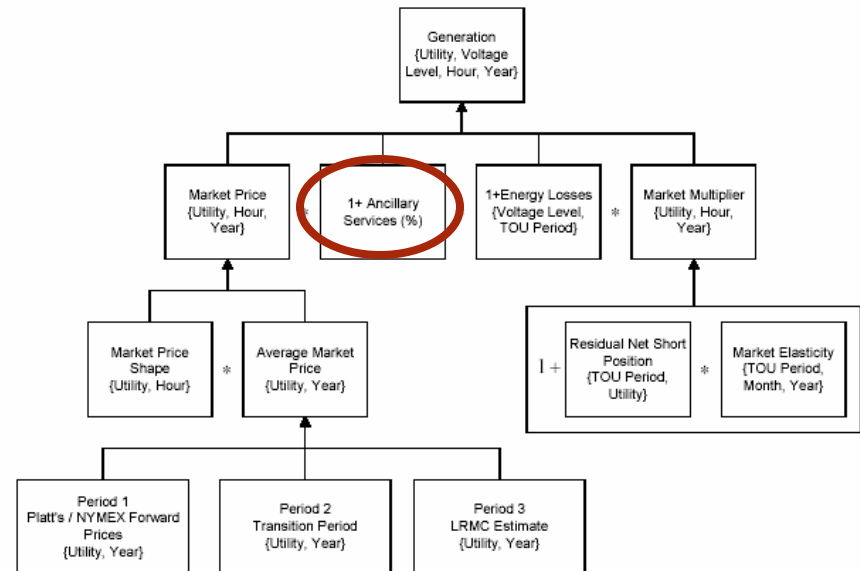
O-1

- For the purpose of this report, reliability benefits are placed in two categories:

1. Benefits that accrue under normal conditions. These comprise reduced purchases of ancillary services by the California Independent System Operator (CAISO). This section describes the methodology for estimating avoided ancillary service costs.

2. Benefits that accrue only under low probability scenarios. These are primarily reduced exposure to volatile market prices in the years before California reaches resource balance. We describe the methodology for calculating these benefits in Section 4.0.

-\$5 to \$15/MWh (1 to 1 reduction of ancillary services procured)



R&D-10

Benefit	Value	Comments
System reliability	<ul style="list-style-type: none"> Nil under base case Reliability improvement in high DER penetration case Magnitude of cost savings not yet studied, but likely to be modest 	<ul style="list-style-type: none"> DER may be able to prevent some outages (those attributable to overloads, some portion of equipment failure and other causes): <ul style="list-style-type: none"> These outages account for 10-30% of all outages Reducing overloading will reduce failure rate However, repair costs due to significant penetration of DER could increase (safety procedures, islanding, etc.)

Appendix C Cost Benefit Summary

Benefits		DG Owner	Utility	Ratepayers	Society
6	Voltage Support to Electric Grid				

O-1

- These services are procured by the CAISO under long-term contract. Reactive power requirements for voltage support might be reduced with lower system peak loads. However, this effect would be extremely difficult to estimate and is likely to be small. We therefore assume in this analysis that load reductions do not result in incremental savings in reactive power requirements.

-\$0MWh

O-3

Methods/Models that can be used to Quantify:

Windmil: Analyzes a system by feeder, substation, or the entire system.

R&D-18

•Network benefits (based on 13.6 MW DR addition and 51.8 MW DG addition):

- Low voltage buses (<1.000 PV) eliminated
- Reduced variability in SVP system voltage profile

O-3 Note: Efficiency solutions don't provide reactive power

Appendix C Cost Benefit Summary

Benefits		DG Owner	Utility	Ratepayers	Society
7	Enhanced Electricity Price Elasticity				

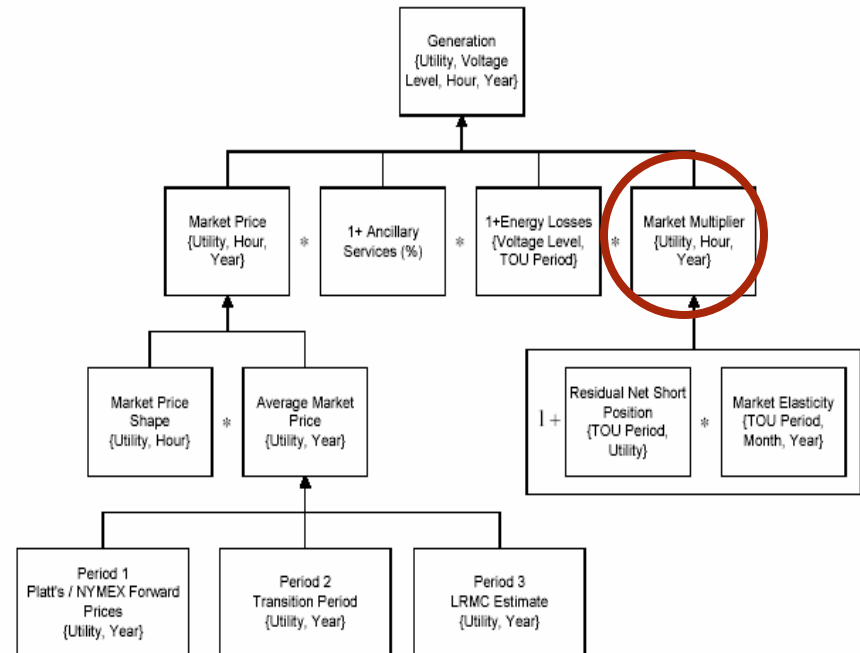
O-1

-This section estimates a stream of hourly values for the years 2004-2023, of the quantified price elasticity of demand benefits resulting from reduced electricity and natural gas consumption. In the context of a deregulated energy market, the price elasticity values should reflect the value of reduced energy usage based on its effect on reducing day-ahead market prices through demand reduction.

- \$0 to \$8.96/MWh (0 to 8% of Market Price+Ancillary+Energy Losses)

O-3 Methods/Models that can be used to Quantify:

Analysis of market outcomes and behavior and/or simulation and auction experiments could be used to estimate potential gain.



Appendix C Cost Benefit Summary

Benefits		DG Owner	Utility	Ratepayers	Society
8	NIMBY Opposition to Plants and Transmission				

O-3 Models or Methodology for Quantification:

Perhaps indirectly by evaluating property value changes in areas where central plants were built and in areas where plants were not built.

O-3 Note: Efficiency solutions don't provide reactive power

Appendix C Cost Benefit Summary



Benefits		DG Owner	Utility	Ratepayers	Society
9	Land Use Effects				

O-3 Methodology for Analysis/Evaluation/Quantification:
There are not readily available methods other than willingness to pay studies of the value of open space, but many of these, e.g. on national parks, do exist.

O-3 Note: Efficiency solutions don't provide reactive power

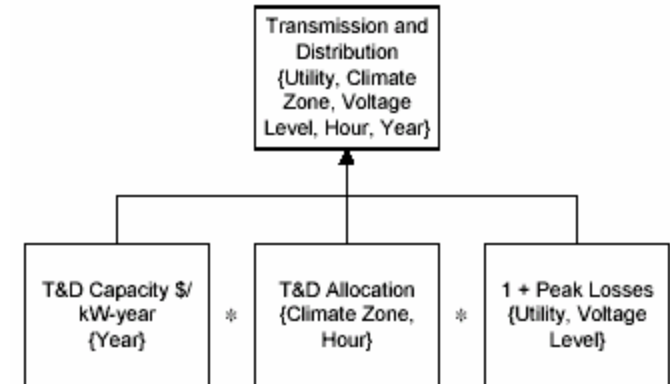
Appendix C Cost Benefit Summary

Benefits		DG Owner	Utility	Ratepayers	Society
10	Avoided T&D Capacity				

O-1

-Values for the quantified cost of electricity and natural gas transmission and distribution (T&D) upgrades and maintenance, in dollars/kWh and dollars/therm respectively, on an annual basis, associated with the years 2004-2023. Because the avoided costs depend upon area-specific capacity conditions as well as individual utility planning criteria and practices, the report relies on investment and load growth data and financial assumptions provided by Pacific Gas & Electric (PG&E), Southern California Edison (SCE), San Diego Gas & Electric (SDG&E) and Southern California Gas (SoCal Gas) to develop the forecasts. In most cases, the needed information is developed by the utilities as part of their normal regulatory filings. E3's forecasts are area- and time-specific. E3 has cross-mapped each utility's electric distribution planning areas to the 16 climate zones specified by the CEC's Title 24 building standards and allocated the annual forecast electric T&D avoided costs to the hours of the year that are the most likely drivers of the local peak demand.

- \$1 to \$16/MWh



O-2

Includes an economic cost-benefit analysis of a single feeder of the uses of distributed generation by utilities for transmission and distribution deferral

O-3 Methods/Models that can be used to Quantify:

- UPLAN-NPM (Network Power Model): Forecasts market price, asset valuation, resource planning and AC/DC load flow.
- Financial Analysis Tool for Electric Energy Projects (FATE2-P): Calculates Cost of Energy or Internal Rate of Return for alternative energy projects. This is a power plant project finance model.
- Remote Power Applications Model (RPAM): Simulates specified remote power system and line extension, and then performs a standard utility revenue requirement calculation to evaluate the economics. The model calculates the stream of revenue requirements to support the capital investments, O&M and other annual payments. The line extension model uses the standard engineering limits of voltage drop and maximum capacity to size the line appropriately. The line extension and remote power system are compared on the basis of the life cycle cost of their two revenue streams.
- GE MAPS: Models transmission topology and the distribution of loads to help predict the dispatch of generation throughout the system. GE-MAPS software can evaluate: spot prices or locational marginal prices (LMP), shadow prices, determination and evaluation of transmission congestion, environmental compliance strategy analysis, siting of new generation, evaluation of assets, and determination of projected revenue streams.

O-3 Note: Efficiency solutions don't provide reactive power

Appendix C Cost Benefit Summary

Benefits		DG Owner	Utility	Ratepayers	Society
10	Avoided T&D Capacity				

R&D-10

Benefit	Value	Comments
Avoided T&D capacity	<ul style="list-style-type: none"> \$0/kW to \$1,535/kW over 20 year life-cycle Include consideration of DG reliability requirements to provide 'firm' capacity Include utility loss savings due to DER because of avoided energy (9% losses) and marginal distribution capacity cost (12% losses) 	<ul style="list-style-type: none"> Varies by location, year and utility At significant penetration levels, value of DER reduces because investments are deferred farther and farther into the future (decreasing returns to additional DER, because of time value, and not every kW of DER offsets highest cost distribution capacity) DER source must have at least sufficient capacity to replace one year's load to achieve some deferral Key drivers of deferral value include: <ul style="list-style-type: none"> Expected local growth (fast load growth reduces time new capacity can be deferred) Siting constraints (can exclude technical options, complicate distribution design, etc.) Ideal target distribution planning area: <ul style="list-style-type: none"> High marginal distribution capacity cost Moderate level of load growth Realizing deferral benefits requires DER to meet reliability requirements DER can help reduce losses, leading to energy savings and limited capital savings Reduced capacity, as seen by transmission system and ISO, could reduce capacity payments and ancillary charges.

Appendix C Cost Benefit Summary

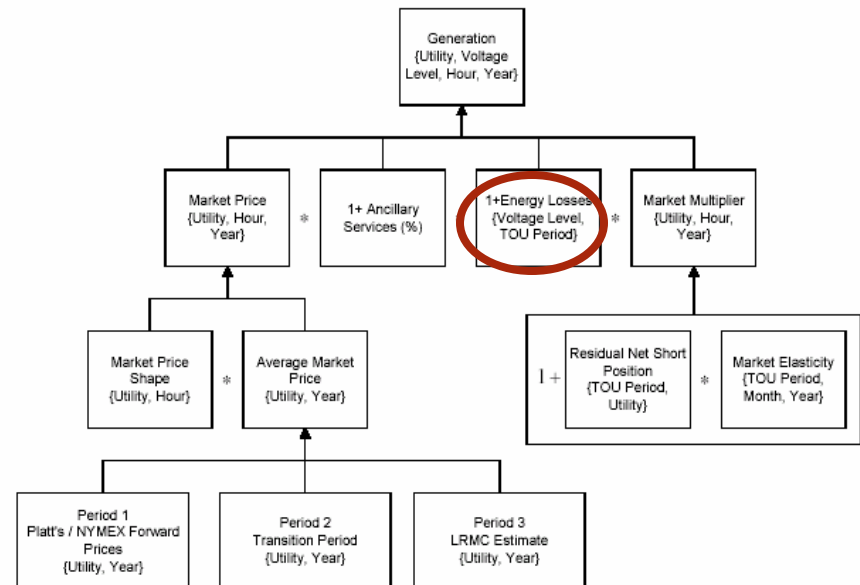
	Benefits	DG Owner	Utility	Ratepayers	Society
11	System Losses				

O-1

Energy losses are the losses from the point of delivery at the customer with the efficiency measure to the hub on the bulk power system. The loss factors represent the average losses for each TOU period and vary by voltage level. For each hour of the year we multiply the avoided cost of generation by one plus the applicable energy loss factor. These losses vary by utility and voltage level, and are given by TOU period.
 -\$0.50 to \$12/MWh (1 to 12% of Market Price+Ancillary Services)

O-3 Methods/Models that can be used to Quantify:

Electric utility planning tools can be used to assess the trade-offs between deploying small DER units and transmission line losses created through long distance transmission of electricity to supply the same load. Power flow models can estimate losses under certain conditions.



R&D-10

Benefit	Value	Comments
Other T&D system benefits	<ul style="list-style-type: none"> Loss savings due to DER in estimation of avoided energy (9% losses) and marginal distribution capacity cost (12% on-peak losses) 	<ul style="list-style-type: none"> DER can provide the following benefit: <ul style="list-style-type: none"> – Voltage support (economic value will often overlap with both capacity and VAR support benefits) – Voltage regulation – Reactive power support – Equipment life extension (in aging facilities, by managing load on equipment) – Reduced maintenance costs (reduced operations and hence maintenance intervals of some equipment), though high DER penetration could increase O&M labor cost.

Appendix C Cost Benefit Summary

Benefits		DG Owner	Utility	Ratepayers	Society
11	System Losses				

R&D-17

Line Loss Savings

- System losses in T&D: 4-7%
- More likely to be quantified on radial distribution lines rather than networked

R&D-18

- DG capacity addition reduces losses by about 20% under light load feeder limit
- Network benefits (based on 13.6 MW DR addition and 51.8 MW DG addition):
 - 31% reduction in P losses in SVP (0.398MW)
 - 30% reduction in Q consumption in SVP (15.203 MVar)
 - Losses reduced at 3x system's average loss rate
 - Around 5MW additional reduced losses in surrounding PG&E system

Appendix C Cost Benefit Summary

Benefits		DG Owner	Utility	Ratepayers	Society
12	Combined Heat Power/ Efficiency Improvement				

O-3

Methods/Models that can be used to Quantify:

- HEATMAP: Designs and evaluates district energy systems, including combined heat and power (cogeneration).
- RECIPRO: Selects and optimizes cogeneration systems for hotels, hospitals, institutional buildings and small industrial applications.
- Cogeneration Ready Reckoner: Does preliminary analysis of the technical and economic potential of cogeneration projects.
- D-Gen Pro: Evaluate the cost-effective application of on-site and distributed power generation.
- DER-CAM: Optimizes customer adoption, it has been developed that looks at on-site electricity and heat requirements and develops an optimal plan for customers to meet this requirement at overall minimum cost over a test period.
- DIStributed Power Economic Rationale SElection (DISPERSE): Assigns electric and thermal load profiles specific to the application and region, and the size of facility is used to "scale" the load profile. Combining this information with DER unit price and performance data, the model performs a life-cycle cost economic analysis, based on the unit life, the cost and performance data, and fuel prices. Baseload electric, cogeneration, and peak shaving operation modes are compared with competing energy prices. The best DER technology option is selected based on the lowest DER competing electricity price.
- The model then compares the annual cost to generate with costs of purchasing from the grid, and adds the application to the potential market if it beats the grid price.
- Clean Energy Technology Economic and Emissions Model (CETEEM): CETEEM was developed to analyze the dynamics of DER and CHP system operation with varying building electrical load profiles, including estimating system performance /efficiency, economics, and lifecycle emissions of criteria pollutants and GHGs.

R&D-10

Benefit	Value	Comments
Annual avoided fuel cost due to waste heat recovery	\$0.005-\$0.06/kWh	Value depends on cost of replaced fuel and the amount of energy recovery.

O-3 Note: Efficiency solutions don't provide reactive power

Appendix C Cost Benefit Summary



Benefits		DG Owner	Utility	Ratepayers	Society
13	Consumer Control				

O-3
The cost of a DER technology (the basic cost of equipment, fuel, operations and maintenance) as provided by vendors and other market suppliers could be compared to the price that the customer is willing to pay for independence.

O-3 Note: Efficiency solutions don't provide reactive power

Appendix C Cost Benefit Summary

Benefits		DG Owner	Utility	Ratepayers	Society
14	Lower Cost of Electricity				

O-3 Identified off the shelf models. Most of these analyze at the project level, except the DISPERSE model.

- Building Energy Analyzer: Estimates annual or monthly loads and costs associated with air-conditioning, heating, power generation, thermal storage and cogeneration systems for a given building and location.
- The Virtual Environment (VE): Among various other capabilities, it can be used to calculate energy consumption and costs.
- ADEPT: Helps optimize the performance and minimize the operating costs associated with electric and gas-powered cooling systems.
- Product Designer: Used to design products that hedge against volatile market prices and quantify impacts on customers' bills.
- Distributed Power Economic Rationale selection (DISPERSE): Assigns electric and thermal load profiles specific to the application and region, and the size of facility is used to "scale" the load profile. Combining this information with DER unit price and performance data, the model performs a life-cycle cost economic analysis, based on the unit life, the cost and performance data, and fuel prices. Baseload electric, cogeneration, and peak shaving operation modes are compared with competing energy prices. The best DER technology option is selected based on the lowest DER competing electricity price. The model then compares the annual cost to generate with costs of purchasing from the grid, and adds the application to the potential market if it beats the grid price.
- D-Gen Pro: Evaluates the cost-effective application of on-site and distributed power generation.
- State-of-the-Art Power Plant (SOAPP): Helps evaluate the costs and benefits of distributed generation opportunities, solving for return on equity (including IRR and payback period) or for bus bar electricity costs.
- DER-CAM: Looks at on-site electricity and heat requirements and develop an optimal plan for customers to meet this requirement at overall minimum cost over a test period.

R&D-10

Benefit	Value	Comments
Annual electricity bill savings	Varies, depending on customer demand and utility tariff (monthly demand, ratcheted demand or coincident demand)	Benefit value depends on fixed charges on the bill (higher fixed charge leads to lower benefit). Utilities are trying to shift more of customer bill from volumetric to fixed charge.

O-3 Note: Efficiency solutions don't provide reactive power

Appendix C Cost Benefit Summary

Benefits		DG Owner	Utility	Ratepayers	Society
15	Consumer Electricity Price Protection				

O-3 Identified Models

If the consumer “sees” the variation in the electricity price, i.e. has a real- time meter installed and buys electricity under an appropriate real-time tariff, the benefit of avoiding price volatility can be evaluated using standard risk evaluation methods.

O-3 Note: Efficiency solutions don’t provide reactive power

Appendix C Cost Benefit Summary

Benefits		DG Owner	Utility	Ratepayers	Society
16	Reliability and Power Quality (DG Owner)				

O-3

Models that can be used to assess reliability and power quality include:

- PQSoft: Produces and stores indices and statistics from power quality monitors. Evaluates the economics of power quality problems along with potential solutions. Analysis and forecasting of voltage sags.
- RAMELEC: Computes the frequency and magnitude of capacity shortages that might be expected in an area given assumptions about supply and demand. Using Monte Carlo simulation, the model determines the outages of generating units for each hour in the study. The difference between the demand forecast and the supply forecast for each simulation provides the probabilistic estimate of supply shortages.

R&D-10

Benefit	Value		Comments
Customer Reliability	Value of Service (VOS) estimates:		<ul style="list-style-type: none"> • Value based on frequency, duration, and timing of utility service interruptions, which determine direct cost, inconvenience and discomfort • Varies by customer class • Value for home office in residential segment and data centers in commercial segment are higher • Depending on the business, value could be as high as \$2 million/hour (pharma companies)
		<u>\$/kwh</u> <u>\$ for 1 hr.</u>	
	Residential	\$4-5 \$4-5	
	Commercial	\$30-50 \$400-600	
	Industrial	\$10-20 \$10,000-20,000	
	Agricultural	\$5-10 \$100 (summer)	

R&D-17

On-site Reliability Benefit	<ul style="list-style-type: none"> • Value of service (VOS) varies by customer situation: <ul style="list-style-type: none"> – Residential VOS around \$1/kWh – Commercial and industrial VOS ranges between \$10-70/kWh – SAIDI and SAIFI used to calculate cost depending on whether duration or number of interruptions or both are relevant
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O-3 Note: Efficiency solutions don't provide reactive power

Appendix C Cost Benefit Summary

Costs		DG Owner	Utility	Ratepayers	Society
1	Utility Revenue Reduction				

R&D-10

Cost	Value	Comments
Revenue reduction due to DER	<ul style="list-style-type: none"> Depends on customer demand and utility tariff 	<ul style="list-style-type: none"> Larger the fixed charge, less lost revenue potential

Appendix C Cost Benefit Summary

Costs	DG Owner	Utility	Ratepayers	Society
Increase in Generation Stranded Assets				

O-3

Methods/Models that can be used to Quantify:

- UPLAN-NPM (Network Power Model): Forecasts market price, asset valuation, resource planning and AC/DC load flow.
- Financial Analysis Tool for Electric Energy Projects (FATE2-P): Calculates Cost of Energy or Internal Rate of Return for alternative energy projects. This is a power plant project finance model.
- Cost of Service Model (COSMO): Computes the area-specific marginal costs resulting from being able to defer, or from having to accelerate, the construction of capacity units due to a change in the capacity requirements.
- Area Investment Models (AIM): Balance capacity investment costs with the potential cost of unserved energy under load growth uncertainty and various reliability criteria.

R&D-13

Technology	Benefits	Value	Issues
PV	Green attributes (green tags)	2.0¢/kwh Range of 4.0-10.0¢/kwh	<ul style="list-style-type: none"> • CPUC issued decision that green tag owned by utility that provides net metering • Decision to be considered in 2003
Biogas	Green attributes (green tags)	5.0¢/kwh	
	Thermal energy recovery	Not quantified	
	Regulatory compliance benefit: <ul style="list-style-type: none"> — Ground water decontamination — Reduction in reactive organic and green house gas emissions (ammonia, methane, nitrous oxide) 	<ul style="list-style-type: none"> • GHG credit of \$1.97 per animal unit per year • Avoided cost of salt contamination removal is \$688 per animal unit (based on O&M cost for reverse osmosis system) 	<ul style="list-style-type: none"> • Ground water decontamination benefit accrues to public agency rather than system owner • Avoided cost impact for ground water decontamination to take five years from start of system operation

O-3 Note: Efficiency solutions don't provide reactive power

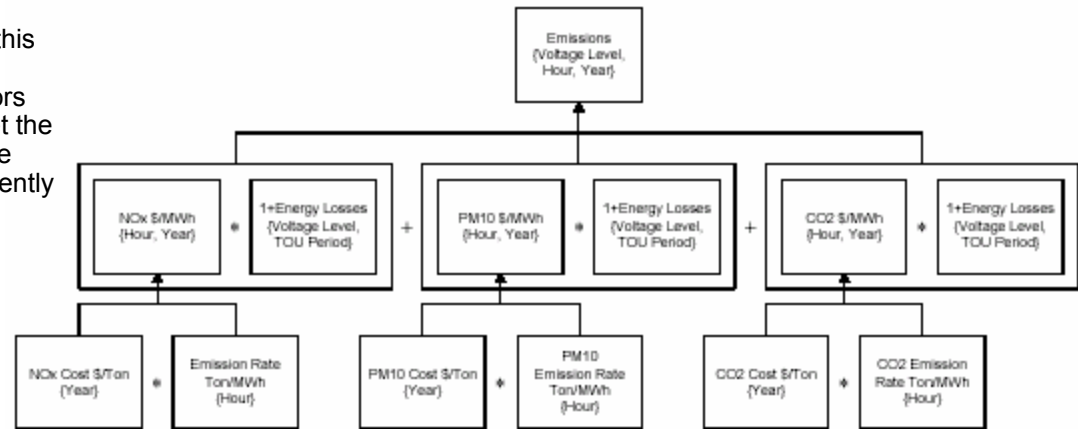
Appendix C Cost Benefit Summary

Costs		DG Owner	Utility	Ratepayers	Society
3	Incentives for Clean Technologies				

O-1

-E3 categorized environmental costs into priced and unpriced emissions, which are accounted for separately in this avoided cost analysis. The priced emissions refer to those emissions that are regulated and for which energy generators must purchase some type of allowances or credits to offset the impact of the emissions produced from their operations. The unpriced emissions represent an externality that is not presently embedded in energy prices and is added directly to the generation and T&D avoided costs.

- \$3 to \$8/MWh



Appendix C Cost Benefit Summary



Costs		DG Owner	Utility	Ratepayers	Society
4	Noise Disturbance				

O-3
Methods/Models that can be used to Quantify:
One method that could estimate the value of this cost, is an economic survey technique, the contingent valuation or “willingness to pay” method. Much of the literature on traffic noise that applies these methods suggests approaches to this problem.

O-3 Note: Efficiency solutions don’t provide reactive power

Appendix C Cost Benefit Summary

Costs		DG Owner	Utility	Ratepayers	Society
5	Indoor Emissions				

O-3

Methods/Models that can be used to Quantify:

- HEATMAP: Studies long-term environmental impacts of existing and proposed systems. Key program features include the capability to analyze air-pollutant emissions, including carbon dioxide, from existing energy sources; compare those levels with air quality that would result after implementation of district energy systems; and determine the effect of environmental taxes.
- Local Scale Modeling of Human Exposure Microenvironments: Models local-scale meteorological and air dispersion that provides ambient air concentrations resulting from transport and other human activities. It can establish the direct relationships between source-to-exposure concentrations specific to the particular exposure microenvironment.

O-3 Note: Efficiency solutions don't provide reactive power

Appendix C Cost Benefit Summary

Costs		DG Owner	Utility	Ratepayers	Society
6	Reduces System Reliability				

R&D-10

Cost	Value	Comments
Other utility (infrastructure and operational cost)	<ul style="list-style-type: none"> Base case assumes no cost 	<ul style="list-style-type: none"> Cost could be incurred for natural gas pipeline compression, ongoing operational costs, such as high level of water usage, etc.

Appendix C Cost Benefit Summary

Costs		DG Owner	Utility	Ratepayers	Society
7	Emissions Offsets				

R&D-10

Cost	Value	Comments
Environmental permitting fees	<ul style="list-style-type: none"> Bay Area Air Quality Management District (BAAMQD) <ul style="list-style-type: none"> Fees for combustion of fuel: <ul style="list-style-type: none"> Initial fee: \$32.52 MMBTU/hr variable, \$179 minimum fees per source, \$62,545 maximum fees per source Permit to operate per source: \$16.76 MMBtu/hr variable, minimum \$128, maximum \$31, 272 Major station source fees (organic compound, SO_x, NO_x, PM₁₀): \$53.35/ton 	<ul style="list-style-type: none"> Applicable for fossil fuel burning DG Varies by air district. Can include the following: <ul style="list-style-type: none"> Administrative fees Combustion of fuel fees Major stationary source fees Excess emission fees In addition to fees, DER customer needs to invest time and resources to get the permit

Patient Information	
Name	
Age	
Gender	
Address	
City	
State	
Zip	
Phone	
Medical History	
Allergies	
Current Medications	
Past Medical History	
Family History	
Social History	
Physical Examination	
Vital Signs	
Laboratory Tests	
Imaging Studies	
Diagnosis	
Treatment Plan	
Follow-up	

Appendix C Cost Benefit Summary



Costs		DG Owner	Utility	Ratepayers	Society
9	DER Fuel Delivery Challenges				

O-3 Methods/Models that can be used to Quantify:
 UPLAN-G: Gas Procurement and Competitive Analysis System: Provides a detailed analysis of all aspects of gas planning including resource portfolio optimization, gas dispatch, pipeline sizing, facilities planning, and demand-side management.

0-3 Note: Efficiency solutions don't provide reactive power

Appendix C Cost Benefit Summary

Costs		DG Owner	Utility	Ratepayers	Society
10	Equipment				

O-3 Identified off the shelf models. Most of these analyze at the project level, except the DISPERSE model.

- Building Energy Analyzer: Estimates annual or monthly loads and costs associated with air-conditioning, heating, power generation, thermal storage and cogeneration systems for a given building and location.
- The Virtual Environment (VE): Among various other capabilities, it can be used to calculate energy consumption and costs.
- ADEPT: Helps optimize the performance and minimize the operating costs associated with electric and gas-powered cooling systems.
- Product Designer: Used to design products that hedge against volatile market prices and quantify impacts on customers' bills.
- Distributed Power Economic Rationale selection (DISPERSE): Assigns electric and thermal load profiles specific to the application and region, and the size of facility is used to "scale" the load profile. Combining this information with DER unit price and performance data, the model performs a life-cycle cost economic analysis, based on the unit life, the cost and performance data, and fuel prices. Baseload electric, cogeneration, and peak shaving operation modes are compared with competing energy prices. The best DER technology option is selected based on the lowest DER competing electricity price. The model then compares the annual cost to generate with costs of purchasing from the grid, and adds the application to the potential market if it beats the grid price.
- D-Gen Pro: Evaluates the cost-effective application of on-site and distributed power generation.
- State-of-the-Art Power Plant (SOAPP): Helps evaluate the costs and benefits of distributed generation opportunities, solving for return on equity (including IRR and payback period) or for bus bar electricity costs.
- DER-CAM: Looks at on-site electricity and heat requirements and develop an optimal plan for customers to meet this requirement at overall minimum cost over a test period.

R&D-3

DG Technology >>	IC Engines	Combustion Turbines	Micro-turbines	Fuel cells
System size	1- 2 MW	1 – 25 MW	30kW	5 – 200 kW
Equipment Cost	\$200/kW (without catalytic reduction)	\$400/kW	\$1,000/kW	\$3,000 - \$30,000/kW (by technology)
Installation Cost	\$160 - 300/kW	\$200 – 1,000/kW	\$1,000 – 2,600/kW	\$800 - \$3,200/kW

R&D-13

Technology	Building Integrated PV	Dairy & Food Processing Waste Biogas (Centralized Anaerobic Digester or CAD)	Wastewater Treatment Plant Biogas	Landfill Biogas
System Cost 2002	\$9/Wac \$6-14/Wac	\$7,950/kW \$5,160-\$10,750/kW	\$3,250/kW (including \$2,000/kW for generation equipment alone)	\$3,680/kW (of which \$2,000/kW is for generation equipment)

Appendix C Cost Benefit Summary

Costs		DG Owner	Utility	Ratepayers	Society
10	Equipment				

R&D-10

Cost	Value	Comments
Annual capital costs	Technology (\$/kW)	<ul style="list-style-type: none"> Varies by equipment manufacturer, technology, size, usage, financing
	Fuel Cells	
	Micro Turbines & ICE	
	Solar	
	Wind	

R&D-17

Technology	Installed Cost	
Diesel generators	<ul style="list-style-type: none"> New: \$500/kW or more Used: \$200/kW 	Peaking Duty DG Cost <ul style="list-style-type: none"> Operate for a few hundred hours per year Installed cost: \$200-500/kW Non-fuel operating cost: 1¢-5¢/kWh
Spark ignited recip engines	<ul style="list-style-type: none"> \$400-600/kW 	
“Conventional” combustion turbine generator	<ul style="list-style-type: none"> Lighter duty, used: \$300/kW Heavier duty, used: \$700-800/kW 	Primary DG for Baseload <ul style="list-style-type: none"> Installed cost: \$400-800/kW Non-fuel operating cost: 0.5¢-3¢/kWh
Microturbines	<ul style="list-style-type: none"> \$1,000-\$1,500/kW 	
Advanced Turbine System (ATS) generators	<ul style="list-style-type: none"> \$400/kW 	CHP <ul style="list-style-type: none"> Can add 25-100% to the installed cost of a generation only system
Fuel cells	<ul style="list-style-type: none"> \$3,000/kW, expected to decline to \$1,000/kW 	
Electrochemical batteries	<ul style="list-style-type: none"> \$200-\$300/kW of power <i>output</i> 	
PV	<ul style="list-style-type: none"> \$5,000 - \$10,000/kW 	

Appendix C Cost Benefit Summary

Costs		DG Owner	Utility	Ratepayers	Society
10	Equipment				

R&D-16

Technology	Size (kW)	Turnkey Cost (\$/kW)	
		2000	2010
Microturbines	30-80	\$1,333-1,700	\$1,333
Fuel Cells	10-3,100	N/A	\$670-1,800
PV	5-100	\$6,675-8,650	\$4,088-5,080
Diesel Backup Generators	15-500	\$318-2,257	\$318-2,257
Gas Fired Recip Engines	25-500	\$833-1,730	\$830-1,420

R&D – 23

PV Life-Cycle Cost of Electricity (numbers in cents/kWh)

Installation	Residential	Commercial	Central PV
- LCOE (without incentives)	27.8 – 34.8	37.9	26.8 – 36.9

Appendix C Cost Benefit Summary

Costs		DG Owner	Utility	Ratepayers	Society
10	Equipment				

R&D-11

Utility Peaking DG

Benefits

- Can provide peaking capacity at lower overall costs than traditional central generation.
- Technologies that are competitive
 - 2002: diesel engines (75% of situation), duel fueled engines (37%), small conventional combustion turbines (32%), spark gas gensets (54%) and ATS (58%)
 - 2010: diesel engines (75% of situation), duel fueled engines (52%), small conventional combustion turbines (79%), spark gas gensets (54%) and ATS (70%), microturbines (75%)

Costs

- Cost effective peaking DG (mainly diesel engines) have higher emissions per unit of energy vs. in-state generation mix. Other technologies cannot serve new load economically but have lower emissions.

•Cost for DG technologies

Technology	2002			2010		
	Installed cost		Variable O&M	Installed cost		Variable O&M
	\$/kW	\$/kW-yr		\$/kW	\$/kW-yr	
Micro-turbine	475	54.6	0.014	400	46.0	0.01
ATS	450	51.8	0.010	425	48.9	0.01
Conventional CT	475	54.6	0.014	400	46.0	0.01
Dual fueled engine	475	54.6	0.023	450	51.8	0.02
Otto/Spark engine	425	48.9	0.027	425	48.9	0.025
Diesel engine	410	47.2	0.025	410	47.2	0.025

Appendix C Cost Benefit Summary

Costs		DG Owner	Utility	Ratepayers	Society
10	Equipment				

R&D-11

Utility Base load DG

Benefits

- DG has difficulty in competing with wholesale market for base load
- Exception: CHP increases economics potential for combustion turbine base DG
- Technologies that are competitive
 - 2002: small conventional combustion turbines (10%), microturbines (4%) and ATS (33%). Fuel cells and engine based solutions are not cost effective
 - 2010: small conventional combustion turbines (16%), microturbines (14%) and ATS (42%), NG gas fuel PEM fuel cells (2%)

Costs

- Incremental cost of CHP is \$230/kW, representing piping, heat exchangers and engineering costs associated with CHP
- Cost effective DG will lead increased air emissions compared to existing in-state generation (though total emissions are likely to increase nominally given reasonable market penetration assumptions)
- Cost for DG technologies

Technology	2002			2010		
	Installed cost		Variable O&M	Installed cost		Variable O&M
	\$/kW	\$/kW-yr		\$/kW	\$/kW-yr	
Micro-turbine	575	66.1	0.01	475	54.6	0.01
ATS	450	51.8	0.010	425	48.9	0.01
Conventional CT	540	62.1	0.009	500	57.5	0.008
Dual fueled engine	525	60.4	0.02	475	54.6	0.018
PEM Fuel Cell	1000	115.0	0.022	918	105.6	0.008
Phosphoric Acid FC	1720	197.8	0.015	1168	134.3	0.01

Appendix C Cost Benefit Summary

Costs		DG Owner	Utility	Ratepayers	Society
10	Equipment				

R&D-11

Customer DG

Benefits

•Benefits to customer include:

- Lower overall energy costs and lower demand charge during peak (only if CHP is combined can DG compete effectively for serving customers needs year round)
- High electric service reliability
- High power quality
- Heat for industrial processes

Costs

•Cost for DG technologies

Technology	2002			2010		
	Installed cost		Non-fuel Variable O&M	Installed cost		Non-fuel Variable O&M
	\$/kW	\$/kW-yr		\$/kW	\$/kW-yr	
Micro-turbine	575	124.7	1.0	475	103.0	1.0
Micro-turbine with ATS	805	174.6	1.0	805	152.9	1.0
Diesel engine	410	88.9	2.5	410	88.9	2.5
ATS with CHP	770	167.0	1.0	655	142.1	1.0
Spark gas engine	475	103.0	2.3	475	103.0	2.1
Phos. Acid Fuel cell	1880	407.8	1.8	918	199.2	0.8

Appendix C Cost Benefit Summary

Costs		DG Owner	Utility	Ratepayers	Society
11	Interconnection (system studies and upgrades)				

O-3 Identified off the shelf models. Most of these analyze at the project level, except the DISPERSE model.

- Building Energy Analyzer: Estimates annual or monthly loads and costs associated with air-conditioning, heating, power generation, thermal storage and cogeneration systems for a given building and location.
- The Virtual Environment (VE): Among various other capabilities, it can be used to calculate energy consumption and costs.
- ADEPT: Helps optimize the performance and minimize the operating costs associated with electric and gas-powered cooling systems.
- Product Designer: Used to design products that hedge against volatile market prices and quantify impacts on customers' bills.
- Distributed Power Economic Rationale selection (DISPERSE): Assigns electric and thermal load profiles specific to the application and region, and the size of facility is used to "scale" the load profile. Combining this information with DER unit price and performance data, the model performs a life-cycle cost economic analysis, based on the unit life, the cost and performance data, and fuel prices. Baseload electric, cogeneration, and peak shaving operation modes are compared with competing energy prices. The best DER technology option is selected based on the lowest DER competing electricity price. The model then compares the annual cost to generate with costs of purchasing from the grid, and adds the application to the potential market if it beats the grid price.
- D-Gen Pro: Evaluates the cost-effective application of on-site and distributed power generation.
- State-of-the-Art Power Plant (SOAPP): Helps evaluate the costs and benefits of distributed generation opportunities, solving for return on equity (including IRR and payback period) or for bus bar electricity costs.
- DER-CAM: Looks at on-site electricity and heat requirements and develop an optimal plan for customers to meet this requirement at overall minimum cost over a test period.

O-3 Note: Efficiency solutions don't provide reactive power

Appendix C Cost Benefit Summary

	Costs	DG Owner	Utility	Ratepayers	Society
11	Interconnection (system studies and upgrades)				

R&D-10

Perspective	Cost	Value	Comments
DG Owner	Interconnection study, equipment and electric system upgrade	<ul style="list-style-type: none"> •\$2,000 •Range spans from \$0 to \$30,000 per DER installation 	<ul style="list-style-type: none"> • Includes engineering study cost (for systems > 1MW) and customer interconnection equipment (utility fees, third party payments, etc.) • System upgrade costs to interconnect DER not included in cost estimate and is location specific
Utility / Ratepayers	Interconnection study and equipment cost		<ul style="list-style-type: none"> • Costs related to engineering study and interconnection equipment, including switching, metering, etc.
Utility / Ratepayers	System upgrade	Base case assumes nil	<ul style="list-style-type: none"> • To allow parallel operation of DER sources >1-2MW, substation upgrades may be required, or distribution feeder lines upgrades • Protective relays and other equipment are needed to disconnect before equipment damage

Appendix C Cost Benefit Summary

Costs		DG Owner	Utility	Ratepayers	Society
12	Fuel				

O-3 Identified off the shelf models. Most of these analyze at the project level, except the DISPERSE model.

- Building Energy Analyzer: Estimates annual or monthly loads and costs associated with air-conditioning, heating, power generation, thermal storage and cogeneration systems for a given building and location.
- The Virtual Environment (VE): Among various other capabilities, it can be used to calculate energy consumption and costs.
- ADEPT: Helps optimize the performance and minimize the operating costs associated with electric and gas-powered cooling systems.
- Product Designer: Used to design products that hedge against volatile market prices and quantify impacts on customers' bills.
- Distributed Power Economic Rationale selection (DISPERSE): Assigns electric and thermal load profiles specific to the application and region, and the size of facility is used to "scale" the load profile. Combining this information with DER unit price and performance data, the model performs a life-cycle cost economic analysis, based on the unit life, the cost and performance data, and fuel prices. Baseload electric, cogeneration, and peak shaving operation modes are compared with competing energy prices. The best DER technology option is selected based on the lowest DER competing electricity price. The model then compares the annual cost to generate with costs of purchasing from the grid, and adds the application to the potential market if it beats the grid price.
- D-Gen Pro: Evaluates the cost-effective application of on-site and distributed power generation.
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- DER-CAM: Looks at on-site electricity and heat requirements and develop an optimal plan for customers to meet this requirement at overall minimum cost over a test period.

R&D-3

DG Technology >>	IC Engines	Combustion Turbines
Fuel	• \$0.06/kWh for diesel and \$0.03/kWh for NG	• \$0.05/kWh for NG

O-3 Note: Efficiency solutions don't provide reactive power

Appendix C Cost Benefit Summary

Costs		DG Owner	Utility	Ratepayers	Society
12	Fuel				

R&D-10

Cost	Value	Comments
O&M Variable	Technology	<ul style="list-style-type: none"> Fuel cost varies by consumption pattern and rate structure (for natural gas)
	(\$/kWh)	
	Fuel Cells 0.023-0.043 Micro Turbines & ICE 0.011- 0.020	

R&D-16

Technology	Size (kW)	O&M Variable (\$/kWh)	
		2000	2010
Microturbines	30-80	\$0-0.015	---
Fuel Cells	10-3,100	N/A	\$0.002-3.0
Diesel Backup Generators	15-500	\$0.000033	\$0.00003
Gas Fired Recip Engines	25-500	\$0.000033	\$0.00003

Appendix C Cost Benefit Summary

Costs	DG Owner	Utility	Ratepayers	Society
13 Maintenance				

O-3 Identified off the shelf models. Most of these analyze at the project level, except the DISPERSE model.

- Building Energy Analyzer: Estimates annual or monthly loads and costs associated with air-conditioning, heating, power generation, thermal storage and cogeneration systems for a given building and location.
- The Virtual Environment (VE): Among various other capabilities, it can be used to calculate energy consumption and costs.
- ADEPT: Helps optimize the performance and minimize the operating costs associated with electric and gas-powered cooling systems.
- Product Designer: Used to design products that hedge against volatile market prices and quantify impacts on customers' bills.
- Distributed Power Economic Rationale selection (DISPERSE): Assigns electric and thermal load profiles specific to the application and region, and the size of facility is used to "scale" the load profile. Combining this information with DER unit price and performance data, the model performs a life-cycle cost economic analysis, based on the unit life, the cost and performance data, and fuel prices. Baseload electric, cogeneration, and peak shaving operation modes are compared with competing energy prices. The best DER technology option is selected based on the lowest DER competing electricity price. The model then compares the annual cost to generate with costs of purchasing from the grid, and adds the application to the potential market if it beats the grid price.
- D-Gen Pro: Evaluates the cost-effective application of on-site and distributed power generation.
- State-of-the-Art Power Plant (SOAPP): Helps evaluate the costs and benefits of distributed generation opportunities, solving for return on equity (including IRR and payback period) or for bus bar electricity costs.
- DER-CAM: Looks at on-site electricity and heat requirements and develop an optimal plan for customers to meet this requirement at overall minimum cost over a test period.

R&D-3

DG Technology >>	IC Engines	Combustion Turbines	Micro-turbines	Fuel cells
Non fuel O&M Cost (excluding	\$0.01/kWh \$56-150/kW/year	\$0.005/kWh \$24/kW/year	\$0.011/kWh \$89/kW/year	\$0.029-0.06/kWh (with stake replacement) \$344 – 232/kW/year

R&D-13

Technology	Dairy & Food Processing Waste Biogas (Centralized Anaerobic Digester or CAD)	Wastewater Treatment Plant Biogas	Landfill Biogas
O&M Cost	\$0.0325/kWh in 2003, declining at 1% p.a.	\$0.010-0.0165/kWh	\$0.010/kWh for generation equipment

Appendix C Cost Benefit Summary

Costs		DG Owner	Utility	Ratepayers	Society
13	Maintenance				

R&D-10

Cost	Value	
	<u>Technology</u>	<u>(\$/kW-yr)</u>
O&M	Fuel Cells	2-18
	Solar	3-14
	Wind	6-15

R&D-17

Technology	Non-fuel O&M Cost
Diesel generators	• 2.5¢-4.0¢/kWh
Duel fuel diesel engine generators	• 2.5¢-4.0¢/kWh
Spark ignited recip engines	• 2.0¢-4.5¢/kWh
Combustion turbines	• 0.5¢-5.0¢/kWh (Varies by turbine size, age, materials, design, reliability level, etc.)
“Conventional” combustion turbine generator	• 0.75¢-4.0¢/kWh (Varies by duty cycle, maintenance practices)
Advanced Turbine System (ATS) generators	• <0.5¢/kWh
Fuel cells	• 2.5¢-3.0¢/kWh
Electrochemical batteries	• 0.75¢-1.5¢/kWh

Appendix C Cost Benefit Summary

Costs		DG Owner	Utility	Ratepayers	Society
13	Maintenance				

R&D-16

Technology	Size (kW)	O&M Fixed (\$/kW-vr)	
		2000	2010
Microturbines	30-80	\$119	\$119
Fuel Cells	10-3,100	N/A	0-10.8
PV	5-100	\$2.9-14.3	\$2.85-14.3
Diesel Backup Generators	15-500	\$26.5	\$26.5
Gas Fired Recip Engines	25-500	\$26.5	\$26.5

Appendix C Cost Benefit Summary

Costs		DG Owner	Utility	Ratepayers	Society
14	Insurance				

O-3 Identified off the shelf models. Most of these analyze at the project level, except the DISPERSE model.

- Building Energy Analyzer: Estimates annual or monthly loads and costs associated with air-conditioning, heating, power generation, thermal storage and cogeneration systems for a given building and location.
- The Virtual Environment (VE): Among various other capabilities, it can be used to calculate energy consumption and costs.
- ADEPT: Helps optimize the performance and minimize the operating costs associated with electric and gas-powered cooling systems.
- Product Designer: Used to design products that hedge against volatile market prices and quantify impacts on customers' bills.
- Distributed Power Economic Rationale selection (DISPERSE): Assigns electric and thermal load profiles specific to the application and region, and the size of facility is used to "scale" the load profile. Combining this information with DER unit price and performance data, the model performs a life-cycle cost economic analysis, based on the unit life, the cost and performance data, and fuel prices. Baseload electric, cogeneration, and peak shaving operation modes are compared with competing energy prices. The best DER technology option is selected based on the lowest DER competing electricity price. The model then compares the annual cost to generate with costs of purchasing from the grid, and adds the application to the potential market if it beats the grid price.
- D-Gen Pro: Evaluates the cost-effective application of on-site and distributed power generation.
- State-of-the-Art Power Plant (SOAPP): Helps evaluate the costs and benefits of distributed generation opportunities, solving for return on equity (including IRR and payback period) or for bus bar electricity costs.
- DER-CAM: Looks at on-site electricity and heat requirements and develop an optimal plan for customers to meet this requirement at overall minimum cost over a test period.

R&D-10

Cost	Value	Comments
Insurance	<ul style="list-style-type: none"> • Base case assumes no cost 	<ul style="list-style-type: none"> • Utilities may require DER customers to provide insurance (could be \$100,000 in homeowner's policy coverage)

O-3 Note: Efficiency solutions don't provide reactive power

Appendix C Cost Benefit Summary



Costs		DG Owner	Utility	Ratepayers	Society
15	Exemptions from Cost Responsibility Surcharges				

CPUC-9
CRS charges capped at \$0.027/kWh

Appendix D Cost Benefit Inventory



Appendix D – Cost Benefit Inventory

Appendix D

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Identification		Quantification		Market Mechanisms		



Installation, Operation and Maintenance Costs for DG; EPRI, February 2003 (R&D-3)

Key Findings / Recommendations / Notes Etc					
Identification of Costs <ul style="list-style-type: none"> Costs associated with DG <ul style="list-style-type: none"> Equipment Cost Installation Cost Non-fuel Operations and Maintenance Cost Fuel Cost Installation cost includes: <ul style="list-style-type: none"> Project engineering Permitting Site preparation Mechanical systems Fuel supply system Electrical system Site commissioning & design Other Non-fuel O&M cost includes <ul style="list-style-type: none"> Consumables Labor and material associated with maintenance 	DG Technology >>	IC Engines	Combustion Turbines	Micro-turbines	Fuel cells
	System size	1- 2 MW	1 – 25 MW	30kW	5 – 200 kW
	Equipment Cost	\$200/kW (without catalytic reduction)	\$400/kW	\$1,000/kW	\$3,000 - \$30,000/kW (by technology)
	Installation Cost	\$160 - 300/kW	\$200 – 1,000/kW	\$1,000 – 2,600/kW	\$800 - \$3,200/kW
	Non fuel O&M Cost (excluding	\$0.01/kWh \$56-150/kW/year	\$0.005/kWh \$24/kW/year	\$0.011/kWh \$89/kW/year	\$0.029-0.06/kWh (with stake replacement) \$344 – 232/kW/year
	Comments	<ul style="list-style-type: none"> IC engines equipment cost have negative economies of scale Selective Catalytic reduction (SCR) adds \$100/kW to installation cost Fuel cost = \$0.06/kWh for diesel and \$0.03/kWh for NG 	<ul style="list-style-type: none"> Combustion Turbines equipment cost show economies of scale Addition to installation cost: \$150/kW for heat recovery and \$80/kW for SCR Fuel cost = \$0.05/kWh for NG 	<ul style="list-style-type: none"> Micro-turbines are currently considered early commercial. Hence not much data on O&M Installation cost expected to reduce to 50-60% of equipment cost 	<ul style="list-style-type: none"> Fuel cells are in testing and demo stage (except for PAFC fuel cells)

Appendix D

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Identification		Quantification		Market Mechanisms		



Commonwealth Energy Biogas/PV Mini-Grid Renewable Resource Program, Project Prioritization, CH2M Hill and Itron, August 2003. (R&D-12)

Key Findings/Recommendations/Notes, Etc.

Impact of Renewable Resource Development (at penetration levels < 10% of peak load)

Benefits

- Mini-grid loss reductions, but relatively small
- Significant distribution system improvement deferrals due to reduced feeder loading
- Transmission and sub-transmission deferrals and loss reductions are difficult to identify and quantify because they serve much broader areas.

Other Notes

- No voltage reduction or power factor correction benefits or penalties are identified.
- There might be voltage regulation issues if sufficient renewable resource is placed at end of a feeder.
- Voltage flicker is not expected to be a problem.
- Voltage regulation concerns can occur due to reverse power flows, with sufficient renewable resources placed on a feeder.

Appendix D

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Identification	Quantification			Market Mechanisms		



San Francisco PUC/Hetch Hetchy Baseline Data Report for DG Assessment Project, Draft Document, August 2003. (R&D-20)

Key Findings/Recommendations/Notes, Etc.

Renewable DG Value Map: Intangible Value Streams

Emission Reduction Value

- Reduced NO_x
- Reduced SO_x
- Reduced CO₂
- Reduced particulates

Feel Good Value

- Political capital
- Increased visibility
- Reduced towers/lines/equipment (aesthetics)

Fuel-Related Value

- Hedge fuel price volatility
- Non-depletable resource
- Energy supply security

Environmental Value

- Protection against future environmental regulation
- Reduced permitting time/cost
- Reduced water usage
- Reduced decommissioning cost

Renewable Type Specific Value

- Reduced roofing material
- Infant industry development (?)
- Increase land value
- Reduced disposal fees

Location

- Local energy value
- Reduce wheeling cost
- Increase local tax base
- Increase local property value
- Local control of resources
- VAR support
- Avoid future T&D upgrades

Unit Size

- Module installation – shorter lead time
- Modular installation hedge against local forecast uncertainty
- Reduced carry costs

Other

- Reliability hedge value – backup power
- Positive local economic impact
- DG penetration network control

Appendix D

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification		Market Mechanisms		



Commonwealth Energy Biogas/PV Minigrid Renewables Resources Program, by Itron Inc., July 2003. (R&D-13)

Key Findings/Recommendations/Notes, Etc.				
Cost Related (All Costs in 2002 \$)				
Technology	Building Integrated PV	Dairy & Food Processing Waste Biogas (Centralized Anaerobic Digester or CAD)	Wastewater Treatment Plant Biogas	Landfill Biogas
System Cost 2002: Typical Range	\$9/Wac \$6-14/Wac	\$7,950/kW \$5,160-\$10,750/kW	\$3,250/kW (including \$2,000/kW for generation equipment alone)	\$3,680/kW (of which \$2,000/kW is for generation equipment)
O&M Cost		\$0.0325/kWh in 2003, declining at 1% p.a.	\$0.010-0.0165/kWh	\$0.010/kWh for generation equipment
Cost of Electricity 2002 2012	12.6-17.4¢/kwh 7.0-12.0¢/kwh			
Issues				<ul style="list-style-type: none"> Landfill should be active and open for at least four years Permitting for landfill bio reactors can be prohibitive

Appendix D

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Identification		Quantification		Market Mechanisms		



Commonwealth Energy Biogas/PV Minigrid Renewables Resources Program, by Itron Inc., July 2003. (R&D-13) *continued*

Key Findings/Recommendations/Notes, Etc.			
Benefits Related			
Technology	Benefits	Value	Issues
PV	Green attributes (green tags)	2.0¢/kwh Range of 4.0-10.0¢/kwh	<ul style="list-style-type: none"> CPUC issued decision that green tag owned by utility that provides net metering Decision to be considered in 2003
Biogas	Green attributes (green tags)	5.0¢/kwh	
	Thermal energy recovery	Not quantified	
	Regulatory compliance benefit: <ul style="list-style-type: none"> Ground water decontamination Reduction in reactive organic and green house gas emissions (ammonia, methane, nitrous oxide) 	<ul style="list-style-type: none"> GHG credit of \$1.97 per animal unit per year Avoided cost of salt contamination removal is \$688 per animal unit (based on O&M cost for reverse osmosis system) 	<ul style="list-style-type: none"> Ground water decontamination benefit accrues to public agency rather than system owner Avoided cost impact for ground water decontamination to take five years from start of system operation

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Identification		Quantification		Market Mechanisms		

A framework for developing collaborative DER Programs: Working Tools for Stakeholders; Draft Report, E21 DER Partnership, December 2003. (R&D-10)

Key Findings/Recommendations/Notes, Etc.

Identification

- Several stakeholder perspectives need to be identified:
 - DER customer
 - Utility rate payer (generally defined as non-participating rate payers)
 - Utility shareholders of IOUs
 - Society

Utility rate payers and utilities are grouped together in this analysis (rate case determines allocation of cost and benefit between them).
- Perspectives can be further classified by:
 - Definition of utility (vertically integrated transmission company, distribution company, energy service provider, etc.)
 - DER ownership (utility, customer, third party)

Quantification

- Participant Cost Test (PCT):
 - Life cycle net benefits for customer that installs the DER
- Rate-payer Impact Measure (RIM):
 - Impact on utility rates
 - Benefits included are capacity cost savings (deferral of wires investment, changes in O&M costs), avoided energy purchase, increased system reliability, other T&D system benefits
 - Costs include incentives paid by utility to providers of the DER, utility administration costs, lost revenues due to reduced sales
- Total Resource Cost Test (TRC):
 - Broader perspective, includes all direct cash costs associated with the DER measure
 - Costs include life cycle cost of the DER measure, O&M costs, program administration costs, interconnection costs
 - Benefits include avoided costs of T&D, generation capacity and energy, including losses
 - Transfers (incentive payments between utility and customers and bill savings) are not considered since the net is zero from the perspective of both
- Societal Cost Test:
 - In addition to TRC test, includes any environmental externalities (e.g., benefit of reduced air emissions)

Appendix D

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Identification		Quantification		Market Mechanisms		



A framework for developing collaborative DER Programs: Working Tools for Stakeholders; Draft Report, E21 DER Partnership, December 2003. (R&D-10) *continued*

Key Findings/Recommendations/Notes, Etc.						
Cost of DER						
Perspective	Cost	Value				Comments
Customer	Annual capital costs, O&M, fuel costs	<u>Technology</u>	<u>Capital Cost (\$/kw)</u>	<u>O&M Fixed (\$/kW-yr)</u>	<u>O&M Variable (\$/kWh)</u>	<ul style="list-style-type: none">Varies by equipment manufacturer, technology, size, usage, financingFuel cost varies by consumption pattern and rate structure (for natural gas)
		Fuel Cells	2,800-5,500	2-18	0.023-0.043	
		Micro Turbines & ICE	1,929-2,604	---	0.011-0.020	
		Solar	6,675-8,650	3-14	---	
		Wind	1,200-6,055	6-15	---	
	Environmental permitting fees	<ul style="list-style-type: none">Bay Area Air Quality Management District (BAAMQD)<ul style="list-style-type: none">Fees for combustion of fuel:<ul style="list-style-type: none">Initial fee: \$32.52 MMBTU/hr variable, \$179 minimum fees per source, \$62,545 maximum fees per sourcePermit to operate per source: \$16.76 MMBtu/hr variable, minimum \$128, maximum \$31, 272Major station source fees (organic compound, SO_x, NO_x, PM₁₀): \$53.35/ton				<ul style="list-style-type: none">Applicable for fossil fuel burning DGVaries by air district. Can include the following:<ul style="list-style-type: none">Administrative feesCombustion of fuel feesMajor stationary source feesExcess emission feesIn addition to fees, DER customer needs to invest time and resources to get the permit

Appendix D

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Identification		Quantification		Market Mechanisms		



A framework for developing collaborative DER Programs: Working Tools for Stakeholders; Draft Report, E21 DER Partnership, December 2003. (R&D-10) *continued*

Key Findings/Recommendations/Notes, Etc.			
Cost of DER			
Perspective	Cost	Value	Comments
Customer (continued)	Interconnection study, equipment and electric system upgrade	<ul style="list-style-type: none"> \$2,000 Range spans from \$0 to \$30,000 per DER installation 	<ul style="list-style-type: none"> Includes engineering study cost (for systems > 1MW) and customer interconnection equipment (utility fees, third party payments, etc.) System upgrade costs to interconnect DER not included in cost estimate and is location specific
	Insurance	<ul style="list-style-type: none"> Base case assumes no cost 	<ul style="list-style-type: none"> Utilities may require DER customers to provide insurance (could be \$100,000 in homeowner's policy coverage)
	Other utility (infrastructure and operational cost)	<ul style="list-style-type: none"> Base case assumes no cost 	<ul style="list-style-type: none"> Cost could be incurred for natural gas pipeline compression, ongoing operational costs, such as high level of water usage, etc.

Appendix D

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Identification		Quantification		Market Mechanisms		



A framework for developing collaborative DER Programs: Working Tools for Stakeholders; Draft Report, E21 DER Partnership, December 2003. (R&D-10) *continued*

Key Findings/Recommendations/Notes, Etc.																	
Benefits of DER																	
Perspective	Benefit	Value	Comments														
Customer	Annual electricity bill savings	Varies, depending on customer demand and utility tariff (monthly demand, ratcheted demand or coincident demand)	Benefit value depends on fixed charges on the bill (higher fixed charge leads to lower benefit). Utilities are trying to shift more of customer bill from volumetric to fixed charge.														
	Annual avoided fuel cost due to waste heat recovery	\$0.005-\$0.06/kWh	Value depends on cost of replaced fuel and the amount of energy recovery.														
	Wholesale Energy Sales	<ul style="list-style-type: none">Avoided energy cost for the utilityBase case value = nil	Valid only if customer sells energy to wholesale electricity market. Base case assumes no sales.														
	Renewable Energy Credit	\$0.0-\$15/MWh	Valid only for renewable energy														
	Customer Reliability	Value of Service (VOS) estimates: <table><thead><tr><th></th><th>\$/kwh</th><th>\$ for 1 hr.</th></tr></thead><tbody><tr><td>Residential</td><td>\$4-5</td><td>\$4-5</td></tr><tr><td>Commercial</td><td>\$30-50</td><td>\$400-600</td></tr><tr><td>Industrial</td><td>\$10-20</td><td>\$10,000-20,000</td></tr><tr><td>Agricultural</td><td>\$5-10</td><td>\$100 (summer)</td></tr></tbody></table>		\$/kwh	\$ for 1 hr.	Residential	\$4-5	\$4-5	Commercial	\$30-50	\$400-600	Industrial	\$10-20	\$10,000-20,000	Agricultural	\$5-10	\$100 (summer)
	\$/kwh	\$ for 1 hr.															
Residential	\$4-5	\$4-5															
Commercial	\$30-50	\$400-600															
Industrial	\$10-20	\$10,000-20,000															
Agricultural	\$5-10	\$100 (summer)															

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Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
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A framework for developing collaborative DER Programs: Working Tools for Stakeholders; Draft Report, E21 DER Partnership, December 2003. (R&D-10) *continued*

Key Findings/Recommendations/Notes, Etc.			
Cost of DER			
Perspective	Benefit	Value	Comments
Utility*	Revenue reduction due to DER	<ul style="list-style-type: none"> Depends on customer demand and utility tariff 	<ul style="list-style-type: none"> Larger the fixed charge, less lost revenue potential
	Interconnection study and equipment cost		<ul style="list-style-type: none"> Costs related to engineering study and interconnection equipment, including switching, metering, etc.
	System upgrade	Base case assumes nil	<ul style="list-style-type: none"> To allow parallel operation of DER sources >1-2MW, substation upgrades may be required, or distribution feeder lines upgrades Protective relays and other equipment are needed to disconnect before equipment damage
	Incentives to DER customers	Base case assumes nil	<ul style="list-style-type: none"> Can be a cost to the utility, depending on who provides the incentive

*Utility rate payers (generally defined as non-participating rate payers) and utility shareholders of IOU are grouped together for this analysis (allocation of costs and benefits between them would be determined in a rate case)

Appendix D

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A framework for developing collaborative DER Programs: Working Tools for Stakeholders; Draft Report, E21 DER Partnership, December 2003. (R&D-10) *continued*

Key Findings/Recommendations/Notes, Etc.			
Benefits of DER			
Perspective	Benefit	Value	Comments
Utility*	Avoided wholesale energy purchases	<ul style="list-style-type: none"> Forward electricity contracts for short term (firm prices includes energy and capacity) Long-term power costs for long term 	<ul style="list-style-type: none"> System wide benefit of DER is lower market prices (reduces output from high marginal production cost, mitigates capacity shortage and counters energy seller's market power) California Measurement Advisory Committee (CALMAC) acknowledges importance of price effect of system demand reduction. It estimates the on-peak escalator at 5x if market power is exercised and 2.5x if market power conditions are mitigated.
	Avoided T&D capacity	<ul style="list-style-type: none"> \$0/kW to \$1,535/kW over 20 year life-cycle Include consideration of DG reliability requirements to provide 'firm' capacity Include utility loss savings due to DER because of avoided energy (9% losses) and marginal distribution capacity cost (12% losses) 	<ul style="list-style-type: none"> Varies by location, year and utility At significant penetration levels, value of DER reduces because investments are deferred farther and farther into the future (decreasing returns to additional DER, because of time value, and not every kW of DER offsets highest cost distribution capacity) DER source must have at least sufficient capacity to replace one year's load to achieve some deferral

*Utility rate payers (generally defined as non-participating rate payers) and utility shareholders of IOU are grouped together for this analysis (allocation of costs and benefits between them would be determined in a rate case)

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A framework for developing collaborative DER Programs: Working Tools for Stakeholders; Draft Report, E21 DER Partnership, December 2003. (R&D-10) *continued*

Key Findings/Recommendations/Notes, Etc.			
Benefits of DER			
Perspective	Benefit	Value	Comments
Utility* (continued)	Avoided T&D capacity (continued)		<ul style="list-style-type: none"> Key drivers of deferral value include: <ul style="list-style-type: none"> Expected local growth (fast load growth reduces time new capacity can be deferred) Siting constraints (can exclude technical options, complicate distribution design, etc.) Ideal target distribution planning area: <ul style="list-style-type: none"> High marginal distribution capacity cost Moderate level of load growth Realizing deferral benefits requires DER to meet reliability requirements DER can help reduce losses, leading to energy savings and limited capital savings Reduced capacity, as seen by transmission system and ISO, could reduce capacity payments and ancillary charges.
	Customer payment for interconnection study	<ul style="list-style-type: none"> \$2,000 Range span \$0 to \$30,000 per DER installation 	<ul style="list-style-type: none"> Includes engineering study cost and customer interconnection costs (equipment utility must install for customer to connect safely, switching, metering, administration)

*Utility rate payers (generally defined as non-participating rate payers) and utility shareholders of IOU are grouped together for this analysis (allocation of costs and benefits between them would be determined in a rate case)

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A framework for developing collaborative DER Programs: Working Tools for Stakeholders; Draft Report, E21 DER Partnership, December 2003. (R&D-10) *continued*

Key Findings/Recommendations/Notes, Etc.			
Benefits of DER			
Perspective	Benefit	Value	Comments
Utility* (continued)	System reliability	<ul style="list-style-type: none"> • Nil under base case • Reliability improvement in high DER penetration case • Magnitude of cost savings not yet studied, but likely to be modest 	<ul style="list-style-type: none"> • DER may be able to prevent some outages (those attributable to overloads, some portion of equipment failure and other causes): <ul style="list-style-type: none"> – These outages account for 10-30% of all outages – Reducing overloading will reduce failure rate – However, repair costs due to significant penetration of DER could increase (safety procedures, islanding, etc.)
	Other T&D system benefits	<ul style="list-style-type: none"> • Loss savings due to DER in estimation of avoided energy (9% losses) and marginal distribution capacity cost (12% on-peak losses) 	<ul style="list-style-type: none"> • DER can provide the following benefit: <ul style="list-style-type: none"> – Voltage support (economic value will often overlap with both capacity and VAR support benefits) – Voltage regulation – Reactive power support – Equipment life extension (in aging facilities, by managing load on equipment) – Reduced maintenance costs (reduced operations and hence maintenance intervals of some equipment), though high DER penetration could increase O&M labor cost.

*Utility rate payers (generally defined as non-participating rate payers) and utility shareholders of IOU are grouped together for this analysis (allocation of costs and benefits between them would be determined in a rate case)

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A framework for developing collaborative DER Programs: Working Tools for Stakeholders; Draft Report, E21 DER Partnership, December 2003. (R&D-10) *continued*

Key Findings/Recommendations/Notes, Etc.			
Benefits of DER			
Perspective	Benefit	Value	Comments
Society	Reduced central station emissions	<ul style="list-style-type: none"> Emission reduction credits NO_x abatement technologies for 150MW facility cost 0.117¢-0.289¢/kWh Permitting fees for engines in South Coast Air Quality Management District ranges between \$184-\$2,088 depending on new/renewal engine fee and size of engine. Source testing costs \$2,000-\$4,000 per test every three years. CO₂ emission offset cost ranges between \$3-12/ton CO₂ emitted (in Oregon) 	<ul style="list-style-type: none"> Valid for renewable technologies For fossil technologies, same or lower relative to central station Abatement equipment cost avoided or reduced Reduced permitting costs if DER is exempt from air permitting requirements Avoided CO₂ emission, though currently not regulated except in Oregon DER emission being lower than central station (though can be high for diesel recip engines)

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Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
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Distributed Power Integration Needs Assessment and Testing, DUIT White Paper, April 2001, Distributed Utility Associates (R&D-17)

Key Issues/Questions

- Can DER be integrated *cost effectively* into other utility systems (substation automation, distribution automation, customer billing systems)?
- What benefits, if any, do DER resources provide with regard to voltage regulation, power factor improvement, or other ancillary services?
- Will there be adverse interactions between different types and brands of DER technologies that could create quality problems (e.g., harmonics from inverters)?
- What economic and reliability benefits can utilities expect from automated dispatch capabilities?
- Can DER participate *cost effectively* in ISO/PX bidding procedures for generation supply or customer load on an aggregated basis?

DUIT Project Scope

- Focus on DER integration and aggregation issues
- Evaluate grid interaction problems and benefits
- Provide feasibility and quantify benefits of integrating diverse DER in a distribution system
- Examine current and emerging technologies
- Interconnection technology, equipment performance, command and control, test issues (grid impacts, system protection), etc.
- Economic benefits of location, dispatchability, ancillary benefits and others

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Distributed Power Integration Needs Assessment and Testing, DUIT White Paper, April 2001, Distributed Utility Associates (R&D-17) *continued*

Key Findings/Recommendations/Notes, Etc.		
Cost or Benefit	Calculation	Issues to Realize Benefits
T&D Deferral Benefit	<ul style="list-style-type: none"> Benefit = present value of kW deferred Example provided 	<ul style="list-style-type: none"> DER must be able to be used reliably to serve load If multiple DERs are in place, their unreliability is smoothed out Utilities must take into account DER on their grid (through various means/mechanisms) to exploit benefits DER is not sufficiently proven or prevalent to warrant explicit and separate inclusion in reserve margin calculations Need to develop an accepted methodology so that utility planners can decide location and year for maximum advantage of DER installations
Distribution System Reliability Benefit	<ul style="list-style-type: none"> Qualitative benefits include faster restoration times, improved feeder reliability (reduced stress and overloading) Hard to quantify benefits include customer goodwill and retention, avoided damage claims and/or lawsuits 	
T&D Cost of Accommodating DER	<ul style="list-style-type: none"> Includes the following: <ul style="list-style-type: none"> Hardware upgrades on distribution system Risk of DER unreliability Engineering staff time and study costs Staff training 	
Energy and Demand Savings for Customer	<ul style="list-style-type: none"> Varies by total usage, time-of-use, customer contracts, etc. Calculation takes into account all fixed and variable cost of DER compared to "without DER" Example provided 	

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Distributed Power Integration Needs Assessment and Testing, DUIT White Paper, April 2001, Distributed Utility Associates (R&D-17) *continued*

Key Findings/Recommendations/Notes, Etc. (continued)		
Cost or Benefit	Calculation	Issues to Realize Benefits
On-site Reliability Benefit	<ul style="list-style-type: none"> Value of service (VOS) varies by customer situation: <ul style="list-style-type: none"> Residential VOS around \$1/kWh Commercial and industrial VOS ranges between \$10-70/kWh SAIDI and SAIFI used to calculate cost depending on whether duration or number of interruptions or both are relevant Example provided 	
Power Quality Improvement Benefit	<ul style="list-style-type: none"> Can be calculated similar to on-site reliability, because for many commercial/industrial customers, a momentary outage is as bad as a sustained one 	
Line Loss Savings	<ul style="list-style-type: none"> System losses in T&D: 4-7% More likely to be quantified on radial distribution lines rather than networked 	

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Distributed Power Integration Needs Assessment and Testing, DUIT White Paper, April 2001, Distributed Utility Associates (R&D-17) *continued*

Key Findings/Recommendations/Notes, Etc.		
Benefits for Utility	Benefits for Customers	Other Benefits (including Societal)
<ul style="list-style-type: none"> • Delay, reduce or eliminate need for additional generation, transmission and distribution infrastructure • Firming up voltage • Improving reliability • Improved power quality • Expanded customer services • Reduced line losses and also resulting reduction in T&D and generation capacity • Increased lifetime of components • Peaking resource: • Improved utilization of existing T&D assets (by flattening out load curve) • Hedging against 'block' load growth uncertainty • Other ancillary services, including Reliability Must Run (RMR), Spinning Reserve, Load Frequency Control, Load Following, Scheduling and Unit Commitment, and Black Start Capability 	<ul style="list-style-type: none"> • Reduce energy charge • Reduce demand charge (peak sharing, interruptible loads, power factor improvement) • Improve reliability (standby/emergency power) • Independence from grid (by choice or necessity) • Insurance against risk of high energy price 	<ul style="list-style-type: none"> • Reduced emissions • Higher efficiencies

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Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification		Market Mechanisms		



Distributed Power Integration Needs Assessment and Testing, DUIT White Paper, April 2001, Distributed Utility Associates (R&D-17) *continued*

Key Findings/Recommendations/Notes, Etc.			
Costs	Cost of Technology		
Peaking Duty DG Cost <ul style="list-style-type: none"> Operate for a few hundred hours per year Installed cost: \$200-500/kW Non-fuel operating cost: 1¢-5¢/kWh Primary DG for Baseload <ul style="list-style-type: none"> Installed cost: \$400-800/kW Non-fuel operating cost: 0.5¢-3¢/kWh CHP <ul style="list-style-type: none"> Can add 25-100% to the installed cost of a generation only system 	Technology	Installed Cost	Non-fuel O&M Cost
	Diesel generators	<ul style="list-style-type: none"> New: \$500/kW or more Used: \$200/kW 	<ul style="list-style-type: none"> 2.5¢-4.0¢/kWh
	Duel fuel diesel engine generators		<ul style="list-style-type: none"> 2.5¢-4.0¢/kWh
	Spark ignited recip engines	<ul style="list-style-type: none"> \$400-600/kW 	<ul style="list-style-type: none"> 2.0¢-4.5¢/kWh
	Combustion turbines		<ul style="list-style-type: none"> 0.5¢-5.0¢/kWh Varies by turbine size, age, materials, design, reliability level, etc.
	“Conventional” combustion turbine generator	<ul style="list-style-type: none"> Lighter duty, used: \$300/kW Heavier duty, used: \$700-800/kW 	<ul style="list-style-type: none"> 0.75¢-4.0¢/kWh Varies by duty cycle, maintenance practices
	Microturbines	<ul style="list-style-type: none"> \$1,000-\$1,500/kW 	<ul style="list-style-type: none"> Data being developed

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Distributed Power Integration Needs Assessment and Testing, DUIT White Paper, April 2001, Distributed Utility Associates (R&D-17) *continued*

Key Findings/Recommendations/Notes, Etc. (continued)			
Costs	Cost of Technology (continued)		
	Technology	Installed Cost	Non-fuel O&M Cost
	Advanced Turbine System (ATS) generators (being developed)	• \$400/kW	• <0.5¢/kWh
	Fuel cells	• \$3,000/kW, expected to decline to \$1,000/kW	• 2.5¢-3.0¢/kWh
	Electrochemical batteries	• \$200-\$300/kW of power output	• 0.75¢-1.5¢/kWh
	PV	• \$5,000 - \$10,000/kW	
	Wind		

Note: Data from various sources, including manufacturer estimates. Installed cost varies by location.

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Document Source			
CEC	CEC Res.	CPUC	Other

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Identification		Quantification		Market Mechanisms		



SOW: Distributed Utility Integration Testing (R&D-21)

Key Issues/Questions	
<p>Objective of the Project</p> <ul style="list-style-type: none"> To examine current and emerging technologies and operational concepts, to determine the impact of large number of DER on the electrical distribution system: <ul style="list-style-type: none"> Prove the feasibility and integration of diverse DG and storage technologies in a distribution system Provide a testing ground for observing and measuring interactions between the DG on the distribution system <p>The project will be executed through a full scale Implementation, testing and demonstration of DG in an actual utility installation.</p>	<p>Relevant Tasks of the Project</p> <ul style="list-style-type: none"> <i>DER Procurement Process:</i> Determining what DER equipment is capable of being borrowed, leased, rented and what needs to be purchased (affects “installed” and financing costs) Conduct the prioritized DER tests and acquire data for the DER technologies for a period of 6 months. Special tests include addressing topics, such as islanding, voltage/load support, harmonics, peak shaving, etc.(Affects quantification of benefits.)

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
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SOW: New Power Technologies (R&D-2)

Key Issues/Questions	
Objective of the Project <ul style="list-style-type: none"> Where a DER project or group of projects, including distribution-connected DER, can provide specific T&D network benefits. Value of those network benefits in engineering and economic terms. (Quantify the operational benefits and avoided network improvements. Benefits will be attributed to individual projects, or group of projects, in addition to the portfolio as a whole). A suggested set of financial and non-financial incentives to facilitate the development of DER projects, including locational pricing of energy and real and reactive capacity. Value-sharing, rather than cost-shifting incentives for DER projects that are beneficial to the operation of the T&D network, as well as targeted policy initiatives that will facilitate the recognition and development of beneficial DER projects. 	Notes <ul style="list-style-type: none"> A small municipal utility, SVP will be used to test this methodology, but should be applicable and useful to any party. Quantification of benefits: <ul style="list-style-type: none"> Seasonal and load variation of the benefits will be assessed An example of network benefit quantification includes MWh reduction in losses under each of summer peak, winter peak, and light load conditions Assessment of barriers to optimal DER portfolio projects: <ul style="list-style-type: none"> Regulatory inconsistencies and barriers that could obstruct implementation of optimal DER portfolio projects Interconnection, environmental, siting, land-use and zoning requirements, inconsistencies and barriers

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Final DG Scenario Development Report for Air Quality Impacts of DG, by University of California, Irvine; September 24, 2003. (R&D-7)

Key Findings/Recommendations/Notes, Etc.

Identification - Benefits

- Emergency stand-by power for critical customer loads
- Meet peak power demand
- Improve user power quality
- Provide low-cost total energy in CHP applications
- Where DG applications displaces either direct hydrocarbon emissions or flared gas emissions (from solid landfills, oil fields, or biomass gas emissions, e.g., dairy farm gaseous emission), or replacing old central plants or diesel generators, there are benefits of reduced emission
- DG-CHP technologies (PEM fuel cell, natural gas and diesel ICE, MTG) could lead to reductions in air pollutant emissions in the range of 0-20%, with reduction in CO₂ in the range of 20-40%, depending on heat recovery capacity factors, etc.

Identification - Costs

- Criteria pollutant emissions from some DG technologies (turbines, ICE, MTG), but could be important enough if they are widely accepted
- Evaluation of DG environmental impact is uncertain, given the disparities in the emission standards and DG performance expectation
- Approved ARB DG emission standards for DG < IMW are:
 - CO: 0.100 lbs/MWh
 - VOC: 0.020 lbs/MWh
 - NO_x: 0.070 lbs/MWh
 - PM: corresponding to NG with sulfur content ≤ 1 grain 100 standard cubic feet (scf)

Miscellaneous Issues

- Only the lowest emitting DG technologies (e.g., fuel cells) with significant waste heat recovery are even marginally competitive with emissions performance of modern combined cycle power production from a criteria pollutant emissions perspective.
- Air quality is different from just emissions, because it is affected by factors such as spatial and temporal variations in emissions, mass transport, geography, etc.

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Final DG Scenario Development Report for Air Quality Impacts of DG, by University of California, Irvine; September 24, 2003. (R&D-7) *continued*

Key Issues/Questions

- Investigation into detailed emission measurement and understanding features for various *emerging* DG types is being carried out:
 - Pollutant emission rates
 - Emissions speciations
 - Continuous vs. peak power applicability
 - Size of equipment
 - Availability of fuel
 - Emissions stack height

Document Source			
CEC	CEC Res.	CPUC	Other

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Identification		Quantification		Market Mechanisms		



'Advanced Control Systems for the Grid' and DER, CADER International Symposium, January 2004. (R&D-9)

Key Findings/Recommendations/Notes, Etc.

Identification of Benefits of DER

- DER uniquely valuable as reactive power sources and, hence, reactive power management and voltage support
 - Distributed (many and small), which increases network operational flexibility
 - Local (close to need)
 - Variable output (responsive)

Quantification

- Economic cost of voltage collapse is high, but value of resources that can prevent it is hard to price

Miscellaneous Observation

- Different reactive power configurations are optimal under each load configuration
- Reactive sources are more valuable if they are directly controllable by network operators as load conditions change

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Optimal Portfolio Methodology for Assessing DER Benefits for the Energynet, CADER International Symposium, January 2004. (R&D-18)

Key Issues/Questions	Key Findings/Recommendations/Notes Etc
<ul style="list-style-type: none"> What is the potential of DER to enhance performance of power delivery network? Can benefits be reliability measured and valued? Specific location, size, operating profile of DER project that contributes most to network performance? Most consequential barriers to beneficial DER projects? Can utilities provide incentives for beneficial DER projects by showing value rather than shifting costs? 	<p>Identification of Benefits</p> <ul style="list-style-type: none"> Voltage profile improvements (eliminating low-voltage buses and making overall voltage profile 'flatter') Reduced reactive power flows Reduced electrical losses Stability and power quality improvement Avoided or deferred network additions Dispatchable demand response <p>Note</p> <ul style="list-style-type: none"> Where DER is placed is important to realize benefits Most impact of DER (good and bad) would be invisible in a transmission only analysis <p>Quantification</p> <ul style="list-style-type: none"> Optimal technologies' AEMPFAST® network optimization software (direct voltage optimization through precise placement of hundreds of real and reactive capacity addition through DER) <ul style="list-style-type: none"> P index identifies where adding P capacity is most beneficial to improve network performance Sequential DER capacity additions yield cumulative improvement

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification		Market Mechanisms		



Optimal Portfolio Methodology for Assessing DER Benefits for the Energynet, CADER International Symposium, January 2004. (R&D-18) *continued*

Key Findings/Recommendations/Notes Etc

Quantification (continued)

- Demand Response (DR) capacity additions reduce losses by about 11%
- DG capacity addition reduces losses by about 20% under light load feeder limit
- Network benefits (based on 13.6 MW DR addition and 51.8 MW DG addition):
 - 31% reduction in P losses in SVP (0.398MW)
 - 30% reduction in Q consumption in SVP (15.203 MVar)
 - Losses reduced at 3x system's average loss rate
 - Around 5MW additional reduced losses in surrounding PG&E system
 - Low voltage buses (<1.000 PV) eliminated
 - Reduced variability in SVP system voltage profile
- Easily quantified and priced:
 - Reduced need for energy to make up for real power losses
 - Reduced need for reactive capacity
 - Increased load serving capability where network improvements would otherwise be needed
- Improvement but harder to value:
 - Elimination of low-voltage buses or sectors
 - Reduced reactive power flow
 - 'Flatter' voltage profile for greater stability
 - More network flexibility, reduced impact of contingencies

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CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification		Market Mechanisms		



Distributed Energy Resources with Combined Heat and Power Applications, LBNL, June 2003 (R&D-16)

Key Findings/Recommendations/Notes, Etc.									
Cost Data									
Technology	Size (kW)	Turnkey Cost (\$/kW)		O&M Fixed (\$/kW-yr)		O&M Variable (\$/kWh)		Levelized Cost (¢/kWh)	
		2000	2010	2000	2010	2000	2010	2000	2010
Microturbines	30-80	\$1,333-1,700	\$1,333	\$119	\$119	\$0-0.015	---	10.56-12.14	12.0 – 18.0
Fuel Cells	10-3,100	N/A	\$670-1,800	N/A	0-10.8	N/A	\$0.002-3.0	N/A	6.14-12.36
PV	5-100	\$6,675-8,650	\$4,088-5,080	\$2.9-14.3	\$2.85-14.3	---	---	42.62-55.23	---
Diesel Backup Generators	15-500	\$318-2,257	\$318-2,257	\$26.5	\$26.5	\$0.000033	\$0.00003	4.61-7.48	7.72-16.22
Gas Fired Recip Engines	25-500	\$833-1,730	\$830-1,420	\$26.5	\$26.5	\$0.000033	\$0.00003	7.15-10.42	10.63-13.79

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification		Market Mechanisms		

San Francisco as a Distributed Energy Resource 'Test Bed' Site, M-Cubed, Electrotek Concepts, Energy & Env. Economics, Powerpoint Presentation. (R&D-6)

Key Issues/Questions

Study Objectives

Cost/Benefit

- To provide cost-benefit information geared to utility engineers and planners on the real-world engineering performance and economics of DER:
 - Identify and verify the economic and engineering impact of DER on SF distribution system
 - To pursue a fair assessment of DER/grid interactions
- The above will evaluate issues such as:
 - Value proposition
 - Customer interaction and response
 - Cost and benefits from different perspectives
 - Impact assessment
 - DER characterization
 - Metering/modeling the distribution system
 - Appropriate technologies
 - Load profile impact
- Study to be completed by July 2005 (economic analysis of appropriate technologies to be completed by March 2004)

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification		Market Mechanisms		

Commonwealth Energy Biogas/PV Mini-Grid Renewables Resources Program, by Itron, Draft Report, August 2003 (R&D-14)

Key Findings/Recommendations/Notes, Etc.

Landfill Bio Reactors

- *Benefits* include the following:
 - Offsetting GHG
 - Accelerating the decay of waste matter compacts its volume and increases space available in the landfill
 - Depending on nature of contamination, can treat contaminated ground water
- Issues to be managed include the following, which increases *costs*:
 - Additional liquid is introduced into the landfill, which must be managed
 - Air permit needed

Building Integrated PV

- *Benefits* include the following:
 - Secondary benefits provided by building integrated PV such as roof shading, covered parking structures, etc. (material replacement)
 - Reduction in system losses
 - Deferral of transformer replacements and feeder installation
- *Impact* on T&D is generally small with low penetrations of renewable self generation, and the impact can be either positive or negative
- There may be an *impact* of system instability due to back feed during light load conditions

Appendix D

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Identification		Quantification		Market Mechanisms		



DER Research Assessment Report, Addendum: 2003 Update, NCI (R&D-15)

Key Findings/Recommendations/Notes, Etc.

Cost-Benefit Models

- SAIC is developing a distributed generation analysis tool:
 - To optimize DER in response to market price signals, evaluate DG applications, and predict successful projects
 - Project is funded by DOE
 - Participants include NASEO, DOE, and SAIC
- New power technologies – DER Locational Benefits Modeling Tools:
 - Model will analyze the grid with varying levels of DER penetration, understand benefits of DER, develop tools to understand DER solutions vs. traditional T&D investments, develop market mechanisms to capture and monetize additional DER benefits
 - Funded by CEC
 - Participants include CEC, New Power Technologies, Silicon Valley Power, Silicon Valley Manufacturers Group

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Identification		Quantification		Market Mechanisms		

DER Research Assessment Report, Addendum: 2003 Update, NCI (R&D-15) *continued*

Key Findings/Recommendations/Notes, Etc.

Cost-Benefit Models (continued)

- GIS Development and Power Flow Simulation:
 - Model and analyze grid with varying levels of DER penetration, identify strategic location for using renewable energy DG systems to address electricity system problems (reliability, congestion, and power quality)
 - Funded by CEC, CDF and McNeil Technologies
 - Participants include CEC, McNeil Technologies and California Department of Forestry
- Commonwealth Project 1.1 – Program Planning and Analysis:
 - To model and analyze grid with varying levels of DER penetration, assessment of generation potential, estimates of economic and environmental benefits, specific projects for biogas and PV
 - Funded by CEC
 - Participants include CEC and Commonwealth Energy Corp.

Appendix D

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification		Market Mechanisms		



Distributed Utility Integration Test, PIER, 2 page note (R&D-8)

Key Questions/Issues

DUIT is a full-scale integration test of commercial grade, utility grid interactive DER sponsored by government agencies (including CEC), utilities, and DER technology companies.

Identification

- Better understanding of the benefits and challenges associates with substantial DER penetration into grid.

Quantification

- Knowledge to quantify key benefits from integrating diverse DER into grid.
- Data on viability of DER connected to customer side of meter.

Key Findings/Recommendations/Notes, Etc.

Identification

- Benefits of DER include some or all of the following:
 - Lower energy bills/cost of service
 - Superior service quality
 - High-value energy services
 - Reduced environmental impacts

Appendix D

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification			Market Mechanisms	



Energy Action Plan - May 2003 (CEC-3 and CPUC-1)

Key Issues / Questions

Identification

- Determine system benefits of distributed generation and related costs.
- Determine whether and how to hold distributed generation customers responsible for costs associated with Department of Water Resources power purchases.
- Develop standards so that renewable distributed generation may participate in the Renewable Portfolio Standard program.

Key Findings / Recommendations / Notes Etc

Identification

- The agencies will work together to further develop distributed generation policies, target research and development, track the market adoption of distributed generation technologies, identify cumulative energy system impacts and examine issues associated with new technologies and their use.
- With proper inducements distributed generation will become economic.
- Distributed generation is an important local resource that can enhance reliability and provide high quality power, without compromising environmental quality.

Appendix D

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification		Market Mechanisms		



Distributed Generation Strategic Plan - June 2002 (CEC-1)

Key Issues / Questions

Identification

- What are the local and regional population and environmental impacts from DG technologies and how can these impacts be minimized or mitigated? What are the environmental life cycle impacts of DG compared to central station power plants?
- Assess the “value propositions” that DG could provide to energy consumers and the power system. Determine the best market and regulatory structures needed in California to enable DG to succeed.

Quantification

- How do DG installations great value for the power system? How are these DG projects compensated for that value? What does the customer value? How could a DG project provide that value? How would the customer pay for that value?

Market Mechanisms

- How should market rules be modified to allow DG to better participate in current markets?
- Assess the market, technological and regional potential for distributed generation in California to determine a reasonable goal regarding electric generation capacity additions from DG by 2020.

Key Findings / Recommendations / Notes Etc

Identification

- Participate in policy debate regarding DG market design, utility ownership, utility tariffs, demand charges, standby charges and exit fees.

Quantification

- Conduct research on the potential impacts on populations and the environment from the implementation of DG technologies.
- Develop tools for utilities to assess the value and impact of distributed power at any point on the grid.

Market Mechanisms

- Establish markets that pay for the full value of DG, including grid benefits, environmental benefits, greenhouse gas reduction credits, energy conservation, and waste reduction benefits.
- Identify and address institutional and regulatory barriers, which are interfering with the purchasing, installation, and operation of distributed generation facilities.
- Utility rate design is confusing at best, including issues surrounding standby charges, interconnection fees, exit fees, and grid management charges. The timing of legislative mandates regarding rate design and the ultimate implementation of those policies also carry confusion and uncertainty to DG stakeholders.

Appendix D

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Identification		Quantification		Market Mechanisms		



Integrated Energy Policy Report - December 2003 (CEC-4)

Key Issues / Questions

Quantification

- Much of the focus should be targeted at increasing consumer awareness about the benefits of using distributed generation, providing financial incentives to offset the cost of installation, and funding research to advance technology so that incentives are eventually no longer needed.

Key Findings / Recommendations / Notes Etc

Identification

- DG benefits include improved reliability and power quality, peak-shaving options, security, and efficiency gains through the avoidance of line losses and the use of waste heat for heating and/or air conditioning.
- Distributed generation can benefit utilities by deferring transmission and distribution construction, reducing resource acquisition costs, and supporting the level of ancillary services offered.
- To the extent that electricity generated from renewable resources is sold under long-term contracts, it is immune to fluctuating natural gas prices and helps to stabilize the market, providing real economic benefit

Appendix D

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Identification		Quantification		Market Mechanisms		



Integrated Energy Policy Report Subsidiary Volume: Electricity and Natural Gas Assessment Report - December 2003 (CEC-5)

Key Issues / Questions	Key Findings / Recommendations / Notes Etc
	<p>Identification</p> <ul style="list-style-type: none"> The city (San Francisco) should rely on renewable resources, medium size generation, co-generation, and small scale DG. <p>Market Mechanisms</p> <ul style="list-style-type: none"> Electricity consumption needs that are met by self-generation or distributed generation reduce the demands on the grid. The state should evaluate other alternatives, as a back-up option at the end-user facility. Other alternatives include: using distributed generation as an option to spiking electricity prices or supply shortages,

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification		Market Mechanisms		



Integrated Energy Policy Report Subsidiary Volume: Public Interest Energy Strategies Report - December 2003 (CEC-6)

Key Issues / Questions

Identification

- The Energy Action Plan proposes to promote small, clean generators near load centers, to determine system benefits and costs of DG and promote customer and utility owned distributed generation (DG);

Quantification

- Energy efficiency, demand response, and distributed generation require measurement and evaluation activities that are unlike the instrumentation available to measure conventional generation resources. Evaluations should be used to estimate the peak and annual energy savings (load impacts) of programs and to estimate the uncertainty range around these estimates.
- Reliance upon energy efficiency, demand response, and distributed generation as substitutes for conventional generation requires a commitment to intensive measurement and evaluation. Efforts must be made to determine what measures consumers are willing to choose and the patterns of impacts from these choices. Verifying not only what happened, but how those measures or changes in consumer behavior translate into load impacts by time period will be important.
- The CPUC has initiated a study to determine the appropriate avoided costs in an uncertain market environment. Accurate avoided cost values are necessary to avoid over- or under-investing in efficiency, distributed generation, and demand reduction resources.

Key Findings / Recommendations / Notes Etc

Identification

- The Energy Action Plan identifies public interest strategies: such as to Promote customer and utility owned distributed generation, and proposes that California meet demand and supply needs with conservation and efficiency first, renewable energy and distributed generation second, and if necessary, clean fossil- fuel fired central station generation third.
- Research within the Public Interest Energy Research program at the Energy Commission is fostering development of several new technologies including: Technologies that will change access to electricity, namely electricity storage technologies, and highly efficient and clean distributed generation technologies.

Appendix D

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification		Market Mechanisms		



Integrated Energy Policy Report Subsidiary Volume: Public Interest Energy Strategies Report - December 2003 (CEC-6) *continued*

Key Issues / Questions

Market Mechanisms

- Research can also identify electricity T&D system impacts due to distributed generation deployment, Use of new models to determine grid locations where distributed generation, DER, and electricity storage systems can provide grid support.
- DG in California faces several barriers and uncertainties, including high capital costs, siting and permitting issues, grid interconnection issues, and utility tariffs

Key Findings / Recommendations / Notes Etc

Market Mechanisms

- One of the possible benefits of DG is its potential for reducing transmission constraints. added DG reduces the need to add or upgrade transmission infrastructure in some cases, but in other cases it aggravates congestion.
- Some promising approaches that would permit program synergies between energy efficiency, demand response, and distributed generation include: Increasing the focus on peak load-reductions in energy efficiency programs; Coordinated marketing, information, education, and implementation; Assessing facility equipment and operations; Introducing new technology opportunities; and Integrating efficiency with dynamic pricing and metering.
- The goal of the Action Plan is to decrease per capita energy consumption of electricity through Incorporating...distributed generation or renewable technologies into energy efficiency standards for new building construction.
- Energy efficiency and conservation could be made more responsive by more fully integrating them with demand responsive, renewable, and distributed generation programs.

Appendix D

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Identification		Quantification		Market Mechanisms		



Pre-demonstration Summary Report, task 3.2.5: Micro Scale Technology Demonstration- Project Development and Engineering, Nov 7, 2003 (R&D-19)

Key Issues/Questions

Goal of Task 3.2.5 Micro Scale technology Demonstration:

- Biomass technology demonstration project
- Document costs, energy generation, economic performance, technology performance, emissions and other criteria associated with running the BioMax technology (which is a wood-gas technology, with peak output of 15kWe, and is a small modular bio-power developed by Community Power Corporation of Colorado. This product is in the pre-commercial stage)
- Demonstrate economics of operating small modular biopower systems in distributed generation
- Measure and compare emissions of BioMax with other DG of the same size

Appendix D

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification		Market Mechanisms		



SOW: Commonwealth Program under PIER Renewables (R&D-5)

Key Issues/Questions

Areas of emphasis in the program

1. Assessing and targeting renewable electricity development
2. Increasing affordability by improving existing renewable energy facilities
3. Expanding affordability and diversity using renewable DG
4. Developing renewable technologies for tomorrow's electricity system

Task of interest: 1.1.9: Conduct power flow analysis within mini-grid (mini grid to be defined, in the greater Chino Basin Area)

- Determine potential renewable resource development T&D value
 - Local transmission, sub-transmission and distribution facility deferrals using appropriate T&D and customer service reliability and planning criteria
 - Annual loss reduction in local T&D system
 - Power quality benefits (or penalties) such as T&D voltage control and power factor correction requirements
- Conduct the analysis for different types and mixes of DR, under peak and light load conditions, at different locations, and different penetration levels

Task of interest: 3.1.6 Conduct economic and environmental assessment

- For dairy waste to energy technologies
- Economic assessment to include
 - Capital cost, annual O&M cost, environmental benefits, total life cycle cost (all in dollars)
 - Rate of return (%)
 - Electricity production, average annual output and capacity
- Environmental assessment to include
 - Changes in emission, total dissolved solids, etc

Appendix D

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification		Market Mechanisms		



SOW: San Francisco PUC/ Hetch Hetchy, April 5, 2004 (R&D-22)

Key Issues/Questions		
<p>Project 3.1: DG Assessment</p> <p><u>Objective</u></p> <ul style="list-style-type: none"> To identify best location for DG in local distribution systems, including reliability impacts in the analysis to assess impact of load growth and generator uncertainty on the results. <ul style="list-style-type: none"> Analysis local system impacts and benefits that accrue directly to a municipal UDC Impacts on system reliability (including value to both customers and UDC) Verified and established methodology and tools (for rapid assessment of renewable distributed technology), data, results and recommendations Analysis to be done for each promising technology type 	<p>Project 3.2: Biomass DG valuation analysis and project development for public utility service territories</p> <p><u>Objective</u></p> <ul style="list-style-type: none"> Pursue targeted development and deployment of small modular biomass systems for DG within service territories of at least two public power utilities <ul style="list-style-type: none"> Primary technology focus on small modular biomass <ul style="list-style-type: none"> Micro generation of 15 kW to 50 kW, at load center Small generation in 1-10 MW, for sale to wholesale and retail markets, as stand alone or in combination with storage . Fossil fuel hybrid The project will perform detailed engineering and economic feasibility analysis, document methodology, identify R&D / technology enhancements and project designs needed to develop modular biomass generation systems to meet performance characteristics 	<p>Project 4.3 Energy Storage for renewable generation</p> <p><u>Objective</u></p> <ul style="list-style-type: none"> To assess how application of energy storage might increase the economic effectiveness and value of wind and PV <ul style="list-style-type: none"> Quantify cost effectiveness of existing storage options, including: <ul style="list-style-type: none"> Existing hydro-electric resources Batteries SMES Regenerative fuel cells

Appendix D

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification		Market Mechanisms		



SOW: Energy and Environmental Economics Inc, Electrotek Concepts Inc, San Francisco Co-op DER (R&D-1)

Key Findings/Recommendations/Notes, Etc.

Identification of Benefits

Potential benefits include

- Savings to T&D systems due to deferrals, which vary from area to area and are case specific
- Savings in wholesale power market
- Reduction in power quality problems
- Reduced air emissions
- Ability to meet reliability criteria (e.g. displace Reliability Must Run contracts)
- Local economic benefits
- Other community benefits (reduced noise)
- Peak load reduction
- Loss reduction

Appendix D

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Identification		Quantification		Market Mechanisms		



SOW: Energy and Environmental Economics Inc, Electrotek Concepts Inc, San Francisco Co-op DER (R&D-1) *continued*

Key Issues/Questions	
<u>Objective</u> <ul style="list-style-type: none"> To evaluate real world potential for DER with actual installations To include investigations of the costs, benefits and cost effectiveness of DER options to customers, utilities and society Technical issues uncovered during the process <p>Note: SF Coop to be used as a real world test</p>	<u>Identification and Quantification:</u> <p>Cost Benefit information in each DER technology to include:</p> <ul style="list-style-type: none"> Each stakeholder perspective (DER participant, utility, non-participating ratepayers, society at large) Cost elements such as product purchase, installation, operations and financing Factors that are a challenge to DER will also be included in the analysis: <ul style="list-style-type: none"> Technical problems (interconnection, power quality issues, performance of DER measures) Customer satisfaction and adoption issues Program design problems

Appendix D

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Identification		Quantification		Market Mechanisms		



Air Pollution Emissions Impact Associated with Economic Market Potential of DG in California, DUA, June 2000 (R&D-11)

Key Findings/Recommendations/Notes, Etc.

Utility DG: General notes

Benefits

- Benefits of DG for utilities include:
 - Delay / reduce / eliminate the need for additional generation and T&D infrastructure
 - Provide value added services such as high reliability (utility should allow islanding for reliability credit to be applicable) .
 - US average value for service is assumed at \$3.0/kWh not served. There are 2.5 hours per year of outage, hence reliability benefit is estimated at \$7.5 per kW-year of load
 - Premium power programs
 - Operations of DG in CHP mode reduced air emissions (from avoided boiler operations)
 - Lower line losses (4% on average, 6% during peak hours)
- DG at substations versus feeders
 - If at substations, they do not defer need for a feeder, or improve reliability (most outages occur between substation and load)
- Avoided cost of central generation (compare DG cost against these): Varies between utilities, and within a utility territory. Assumes that DG can provide same or better service reliability and power quality

Application	\$/kW-yr
Base Generation capacity	: 70-90 \$/kW-yr
Peak Generation capacity	: 25-30 \$/kW-yr
Base energy	: 0.0025 \$/kWh
Peak energy	: 0.004 \$/kWh
T capacity	: 5.03 \$/kW-yr
D capacity	: 18.03 \$/kW-yr
Outages	: 7.3 \$/kW-yr

Costs

- Included purchase, installation, financing, depreciation, taxes, fuel, maintenance, overhauls, insurance

Miscellaneous notes

- Costs are in 1999 dollars
- Newer generation plants (central) tend to be cleaner, more efficient and may have lower cost of production. This will affect cost comparison versus DG

Appendix D

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Identification		Quantification		Market Mechanisms		



Air Pollution Emissions Impact Associated with Economic Market Potential of DG in California, DUA, June 2000 (R&D-11) *continued*

Key Findings/Recommendations/Notes, Etc.

Utility Peaking DG

Benefits

- Can provide peaking capacity at lower overall costs than traditional central generation.
- Technologies that are competitive
 - 2002: diesel engines (75% of situation), dual fueled engines (37%), small conventional combustion turbines (32%), spark gas gensets (54%) and ATS (58%)
 - 2010: diesel engines (75% of situation), dual fueled engines (52%), small conventional combustion turbines (79%), spark gas gensets (54%) and ATS (70%), microturbines (75%)

Costs

- Cost effective peaking DG (mainly diesel engines) have higher emissions per unit of energy vs. in-state generation mix. Other technologies cannot serve new load economically but have lower emissions.
- Cost for DG technologies

Technology	2002			2010		
	Installed cost		Variable O&M	Installed cost		Variable O&M
	\$/kW	\$/kW-yr	\$/kWh	\$/kW	\$/kW-yr	\$/kWh
Micro-turbine	475	54.6	0.014	400	46.0	0.01
ATS	450	51.8	0.010	425	48.9	0.01
Conventional CT	475	54.6	0.014	400	46.0	0.01
Dual fueled engine	475	54.6	0.023	450	51.8	0.02
Otto/Spark engine	425	48.9	0.027	425	48.9	0.025
Diesel engine	410	47.2	0.025	410	47.2	0.025

Miscellaneous notes

Appendix D

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification		Market Mechanisms		



Air Pollution Emissions Impact Associated with Economic Market Potential of DG in California, DUA, June 2000 (R&D-11) *continued*

Key Findings/Recommendations/Notes, Etc.

Utility Base load DG

Benefits

- DG has difficulty in competing with wholesale market for base load
- Exception: CHP increases economics potential for combustion turbine base DG
- Technologies that are competitive
 - 2002: small conventional combustion turbines (10%), microturbines (4%) and ATS (33%). Fuel cells and engine based solutions are not cost effective
 - 2010: small conventional combustion turbines (16%), microturbines (14%) and ATS (42%), NG gas fuel PEM fuel cells (2%)

Costs

- Incremental cost of CHP is \$230/kW, representing piping, heat exchangers and engineering costs associated with CHP
- Cost effective DG will lead increased air emissions compared to existing in-state generation (though total emissions are likely to increase nominally given reasonable market penetration assumptions)
- Cost for DG technologies

Technology	2002			2010		
	Installed cost		Variable O&M	Installed cost		Variable O&M
	\$/kW	\$/kW-yr	\$/kWh	\$/kW	\$/kW-yr	\$/kWh
Micro-turbine	575	66.1	0.01	475	54.6	0.01
ATS	450	51.8	0.010	425	48.9	0.01
Conventional CT	540	62.1	0.009	500	57.5	0.008
Dual fueled engine	525	60.4	0.02	475	54.6	0.018
PEM Fuel Cell	1000	115.0	0.022	918	105.6	0.008
Phosphoric Acid FC	1720	197.8	0.015	1168	134.3	0.01

Miscellaneous notes

- Costs are in 1999 dollars

Appendix D

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Identification		Quantification		Market Mechanisms		



Air Pollution Emissions Impact Associated with Economic Market Potential of DG in California, DUA, June 2000 (R&D-11) *continued*

Key Findings/Recommendations/Notes, Etc.

Customer DG

Benefits

- Benefits to customer include:
 - Lower overall energy costs and lower demand charge during peak (only if CHP is combined can DG compete effectively for serving customers needs year round)
 - High electric service reliability
 - High power quality
 - Heat for industrial processes

Costs

- Cost for DG technologies

Technology	2002			2010		
	Installed cost		Non-fuel Variable O&M	Installed cost		Non-fuel Variable O&M
	\$/kW	\$/kW-yr		\$/kW	\$/kW-yr	
Micro-turbine	575	124.7	1.0	475	103.0	1.0
Micro-turbine with ATS	805	174.6	1.0	805	152.9	1.0
Diesel engine	410	88.9	2.5	410	88.9	2.5
ATS with CHP	770	167.0	1.0	655	142.1	1.0
Spark gas engine	475	103.0	2.3	475	103.0	2.1
Phos. Acid Fuel cell	1880	407.8	1.8	918	199.2	0.8

Miscellaneous notes

- Costs are in 1999 dollars

Appendix D

Document Source				Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
CEC	CEC Res.	CPUC	Other	Identification		Quantification		Market Mechanisms		



Relative Merits of Distributed vs. Central Photovoltaic (PV) Generation, Navigant Consulting and Kema-Xenergy, March 2004 (R&D-23)

Key Findings/Recommendations/Notes, Etc.																																												
Benefits		Costs																																										
<ul style="list-style-type: none">Distributed PV benefits:<ul style="list-style-type: none">Commercial building installations can replace curtain wall systems, skylights, awningsEasily sited on customer premises – does not require additional land as can be sited on roof tops (flat and pitched)Reduces T&D losses (5-10%)Defers T&D upgradesHighly visible, providing positive feelings of ownership and environmental stewardshipMinimal O&M requirements and costsReduction of peak utility loadsOther issues<ul style="list-style-type: none">Shading of PV systems through the project life needs to be managedAesthetics may be an issue, though product development efforts are addressing thisFactors that need to be considered for siting PV include building permits and codes, and roof warranties		<ul style="list-style-type: none">Distributed PV (Residential and Commercial) versus Central PV Costs (all data in ¢/kWh) <table><tr><td>Installation</td><td>Residential</td><td>Commercial</td><td>Central PV</td></tr><tr><td>- LCOE (without incentives)</td><td>27.8 – 34.8</td><td>37.9</td><td>26.8 – 36.9</td></tr><tr><td>- Cost incurred by IOU ratepayers (PV system cost)</td><td></td><td></td><td>22.4 – 30.9</td></tr><tr><td>- Cost by IOU ratepayers for T&D losses</td><td></td><td></td><td>3.7 – 5.1</td></tr><tr><td>- Value of incentives</td><td></td><td></td><td></td></tr><tr><td> * by IOU ratepayers (state buy-down)</td><td>11.7 – 15.0</td><td>22.5</td><td></td></tr><tr><td> * by state taxpayers (state income tax credit)</td><td>1.0 – 1.3</td><td>0.9</td><td></td></tr><tr><td> * by federal taxpayers (federal incentives)</td><td></td><td>5.3</td><td>4.4 – 6.1</td></tr><tr><td>- LCOE with incentives</td><td>15.1 – 18.5</td><td>9.2</td><td>26.1 – 36.0</td></tr><tr><td>- Average grid power cost</td><td>12.6 – 25.8</td><td>13.6</td><td>15.1 – 19.8 (peaking plant, with T&D losses)</td></tr></table>			Installation	Residential	Commercial	Central PV	- LCOE (without incentives)	27.8 – 34.8	37.9	26.8 – 36.9	- Cost incurred by IOU ratepayers (PV system cost)			22.4 – 30.9	- Cost by IOU ratepayers for T&D losses			3.7 – 5.1	- Value of incentives				* by IOU ratepayers (state buy-down)	11.7 – 15.0	22.5		* by state taxpayers (state income tax credit)	1.0 – 1.3	0.9		* by federal taxpayers (federal incentives)		5.3	4.4 – 6.1	- LCOE with incentives	15.1 – 18.5	9.2	26.1 – 36.0	- Average grid power cost	12.6 – 25.8	13.6	15.1 – 19.8 (peaking plant, with T&D losses)
Installation	Residential	Commercial	Central PV																																									
- LCOE (without incentives)	27.8 – 34.8	37.9	26.8 – 36.9																																									
- Cost incurred by IOU ratepayers (PV system cost)			22.4 – 30.9																																									
- Cost by IOU ratepayers for T&D losses			3.7 – 5.1																																									
- Value of incentives																																												
* by IOU ratepayers (state buy-down)	11.7 – 15.0	22.5																																										
* by state taxpayers (state income tax credit)	1.0 – 1.3	0.9																																										
* by federal taxpayers (federal incentives)		5.3	4.4 – 6.1																																									
- LCOE with incentives	15.1 – 18.5	9.2	26.1 – 36.0																																									
- Average grid power cost	12.6 – 25.8	13.6	15.1 – 19.8 (peaking plant, with T&D losses)																																									

Appendix D

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification			Market Mechanisms	



CPUC D.00-12-037 – December 2000 (CPUC-2)

Key Issues / Questions

Key Findings / Recommendations / Notes Etc

Identification

- The utilities supported unilateral indemnification, arguing that distributed generation does not benefit ratepayers, and therefore, the utility and its ratepayers should be indemnified from installation of distributed generation.

Appendix D

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification		Market Mechanisms		



CPUC D.01-03-073 – March 2001 (CPUC-3)

Key Findings / Recommendations / Notes Etc

Identification

- Incentives for load control and distributed generation to be paid for enhancing reliability
- Differential incentives for renewable or super clean distributed generation resources.
- Benefits of larger DG units include:
 - greater reduction of grid-supplied electricity,
 - lower installation cost per kW, and,
 - in the case of renewable installations, greater environmental benefits for all Californians
- The statute directs the Commission to adopt incentives for distributed generation to be paid for enhancing reliability, and differential incentives for “renewable or super-clean distributed generation resources.”
- Encourage the deployment of distributed generation in California to reduce the peak electric demand.

Key Findings / Recommendations / Notes Etc

Quantification: Under the program, financial incentives will be provided to distributed generation technologies as follows:

Incentive category	Incentive offered	Maximum percentage of project cost	Minimum system size	Maximum system size	Eligible Technologies
Level 1	\$4.50/ W	50%	30 kW	1 M W	<ul style="list-style-type: none"> ▪ Photovoltaics ▪ Fuel cells operating on renewable fuel ▪ Wind turbines
Level 2	\$2.50/ W	40%	None	1 M W	<ul style="list-style-type: none"> ▪ Fuel cells operating on non-renewable fuel and utilizing sufficient waste heat recovery
Level 3	\$1.00/ W	30%	None	1 M W	<ul style="list-style-type: none"> ▪ Microturbines utilizing sufficient waste heat recovery and meeting reliability criteria ▪ Internal combustion engines and small gas turbines, both utilizing sufficient waste heat recovery and meeting reliability criteria

Appendix D

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification			Market Mechanisms	



CPUC D.03-02-068 – March 2003 (CPUC-7)

Key Issues / Questions

Identification

- The Commission directed the Energy Division to hold a workshop to consider these specific distribution system planning and operations issues:
 - How distributed generation impacts distribution system operations;
 - What changes in operating practices may be needed;
 - How the utilities can identify the level of future deployment of distributed generation; and
 - How this forecast of deployment can be incorporated into the distribution system planning process.
- Consumers will seek (with regard to DG):
 - Technical/Economic – information about technical characteristics (such as fuel consumption, performance, consumption availability), initial cost, operating cost, available financing
 - Safety Issues of distributed generation – hazards to persons and property
 - Interconnection requirements – what are the required equipment and procedures to interconnect a distributed generation unit with the utility grid
 - Consumer Protection – what if any consumer protections will be provided above and beyond existing law and status for electrical devices

Key Findings / Recommendations / Notes Etc

Identification

- Parties identified potential benefits that could result from wide-spread deployment of DG, including:
 - peak demand reduction;
 - deferral of distribution system equipment and upgrades;
 - increased life of distribution equipment;
 - reduction of utility capital risk;
 - power quality improvements;
 - voltage support;
 - line-loss reductions;
 - increase in reliability;
 - environmental benefits;
 - customer satisfaction; and
 - fuel diversity.
- The current availability and flexibility of DG peak shaving technologies such as microturbines, photovoltaics, and wind turbines present potential value both to individual customers and the system by addressing peak demand needs.
- DG increases the life of distribution equipment
- DG has significant potential to reduce system peak demand by serving onsite load. has the potential to release existing generating capacity to meet peak demand requirements of other customers.

Appendix D

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification		Market Mechanisms		



CPUC D.03-02-068 – March 2003 (CPUC-7)

Key Issues / Questions

Identification

- PG&E, SDG&E, and SCE state that distributed generation alone cannot ensure added value to system reliability, without a form of operational guarantee, or physical assurance
- SDG&E identifies four specific conditions that are required if grid benefits from distributed generation are to be realized:
 - distributed generation must be located where SDG&E's planning indicate a need;
 - distributed generation must be installed and operational within the window of time needed by SDG&E;
 - distributed generation must be of appropriate size to accommodate SDG&E's planning needs; and
 - distributed generation must provide physical assurance
- PG&E indicates that solicited distributed generation may also benefit the distribution system by providing voltage support, power factor improvement, and emergency back-up functions.

Key Findings / Recommendations / Notes Etc

Identification

- Distributed generation that exports energy to the grid has a system planning impact because of the potential need for system upgrades to accommodate exported power. Distributed generation that provides grid support also raises system planning issues.

Appendix D

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification			Market Mechanisms	



CPUC D.03-04-030 – April 2003 (CPUC-9)

Key Issues / Questions

Identification

- We also note that several parties to this proceeding refer to our obligation to address valuation of distributed generation benefits and costs both to the overall electric system as well as to individual customers.

Key Findings / Recommendations / Notes Etc

- CRS charges capped at \$0.027/kWh

Appendix D

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification			Market Mechanisms	



CPUC D.03-04-060 – April 2003 (CPUC-8)

Key Issues / Questions

Identification

- The actual costs and benefits of the distributed generation customers receiving special tariffs would be tracked consistent with Resolutions E-3777, E-3778, and E-3779 to achieve appropriate assignment of net costs.

Key Findings / Recommendations / Notes Etc

Identification

- By tracking the actual costs and benefits of distributed generation units receiving rates under §§ 353.3 and 353.13, we can ensure that in each utility's rate design proceeding, any costs are recovered within the customer class and any net costs or benefits are properly assigned, achieving compliance with § 353.13(a).

Appendix D

Document Source			
CEC	CEC Res.	CPUC	Other

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification		Market Mechanisms		



CPUC D.04-01-050 – January 2004 (CPUC-5)

Key Issues / Questions

Identification

- The Energy Action plan adopted by the Commission, the CPA, and the CEC, provides additional support for distributed generation, placing it second in the loading order and enumerating a number of objectives for the state to achieve:
 - Promote clean, small generation resources located at load centers;
 - Determine whether and how to hold distributed generation customers responsible for costs associated with Department of Water Resources power purchases;
 - Determine system benefits of distributed generation and related costs;
 - Develop standards so that renewable distributed generation may participate in the Renewable Portfolio Standard program;
 - Standardize definitions of eligible distributed generation technologies across agencies to better leverage programs and activities that encourage distributed generation;
 - Collaborate with the Air Resources Board, Cal-EPA and representatives of local air quality districts to achieve better integration of energy and air quality policies and regulations affecting distributed generation; and
 - Work together to further develop distributed generation policies, target research and development, track the market adoption of distributed generation technologies, identify cumulative energy system impacts and examine issues associated with new technologies and their use.

Key Findings / Recommendations / Notes Etc

Identification

- Distributed generation and self-generation resources encompass a broad and diverse set of technologies to fit a variety of procurement needs. In addition to providing capacity and energy benefits, they can offer transmission and grid-support benefits that should be included in the utilities' procurement plans

Appendix E



Appendix E – Inventory Coding System

Appendix E Inventory Coding System

Coding System

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Technology		Size		Location		

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Aggregate Peak Demand for Net Metering						

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Data Management		EAP Action		Co-ordination		

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Export	Metering	Dispute	Cost & Fees	Network		

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Identification		Quantification		Market Mechanisms		

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Technology developments		Regulatory & Market Structure		Actions for now		

Def	Gen	C/B	Utility	Net Meter	I/C	Future Tech
Generation		T&D		Planning & Procurement		

Document Source						
CEC	CEC Res.	CPUC	Other			